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AIKEN INDUSTRIES, INC.

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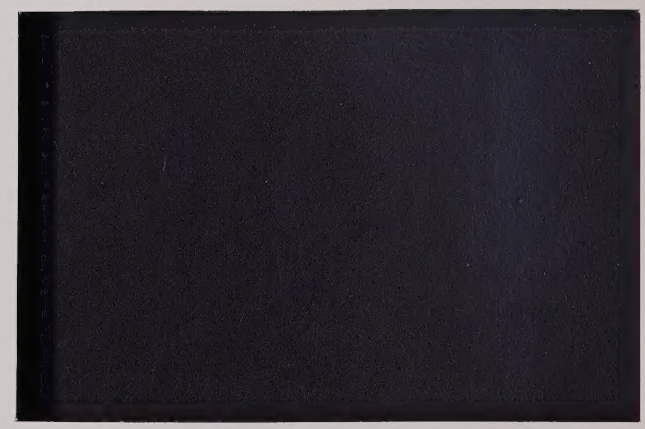
SERIES 810T

810T-400-0.1-1

PRECISION

MULTIPHASE

OSCILLATOR



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REV. B
July, 1972
Behlman

INSTRUCTION MANUAL

SERIES 810T

810T-400-0.1-1

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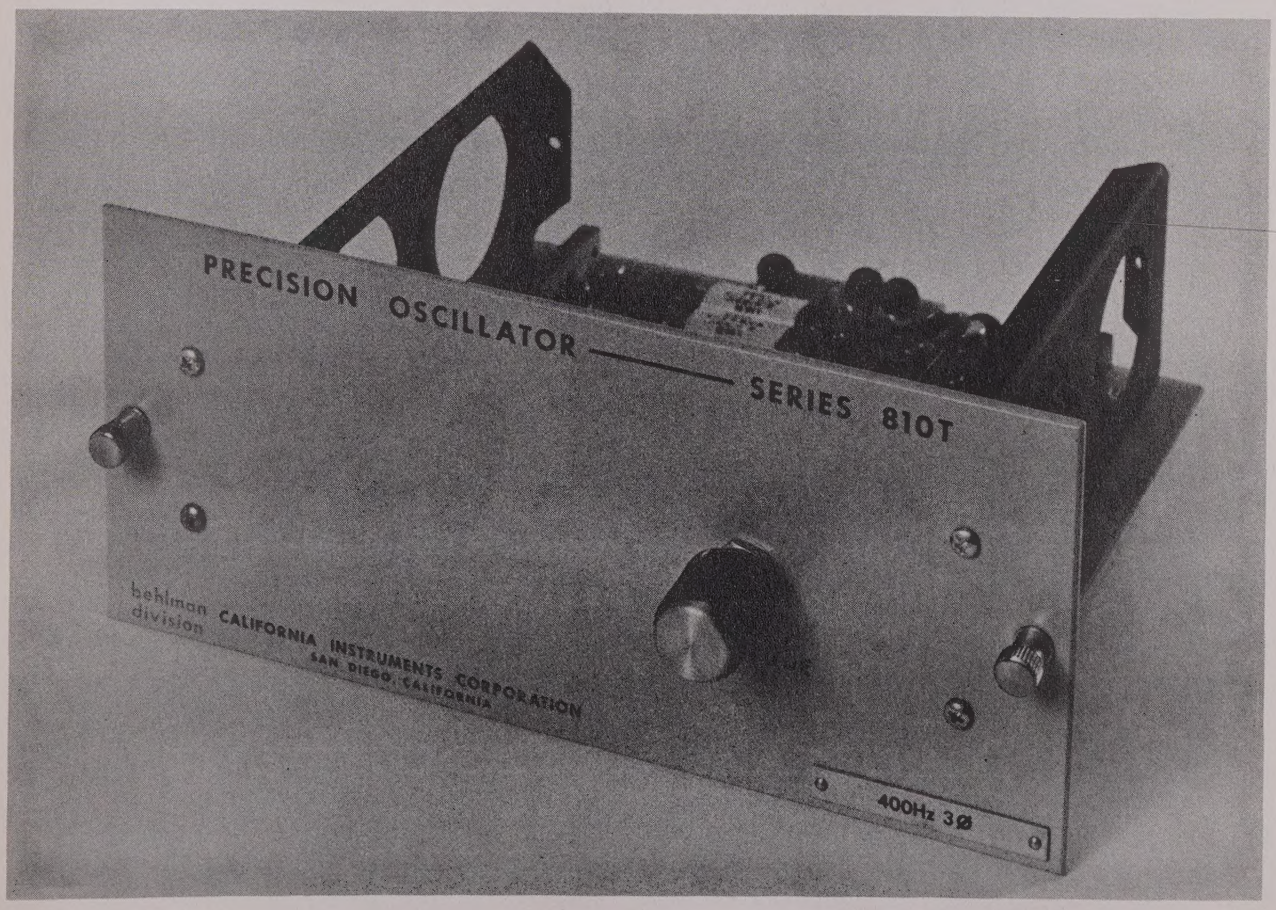

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MODEL 810T-400-0.1-1

The Model 810T-400-0.1-1 provides a single phase 400 Hz ±0.1% output to drive a California Instruments Solid State Invertron®.

See the frequency and phase determining parts list for component values which change with operating frequency.

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SPECIFICATION

All specifications are tested in accordance with standard Behlman test procedures. All specifications apply over the frequency range from 45 Hz to 5 KHz. Minor deviations in distortion and other specifications occur at frequency extremes. Consult applicable manual addendum.

Specifications

	Model 810T-Freq-Tol-1ϕ *	Model 810T-Freq-Tol-3ϕ **	Model 810T-Freq-Tol-2ϕ
NUMBER OF PHASES:	Single Phase	Three Phase	Two Phase
PHASE SEQUENCE:	Not Applicable	ABC Sequence	CA Sequence
PHASE ACCURACY at 25°C:	Not Applicable	±0.25 degree maximum	±0.25 degree maximum
FREQUENCY:	Single Fixed Frequency 45 Hz to 10 KHz	Single Fixed Frequency 45 Hz to 10 KHz	Single Fixed Frequency 45 Hz to 10 KHz
FREQUENCY *** ACCURACY at 25°C:	±0.1 per cent	±0.1 per cent	±0.1 per cent
FREQUENCY TEMPERATURE COEFFICIENT:	±0.01 per cent/°C maximum	±0.01 per cent/°C maximum	±0.01 per cent/°C maximum
OUTPUT AMPLITUDE:	5.000 volts rms ±5 millivolts	0 to greater than 5 volts rms	0 to greater than 5 volts rms
AMPLITUDE STABILITY: (after one hour warm up)	±0.01 per cent for 24 hours at 25°C ±0.0025 per cent/°C maximum	±0.02 per cent for 24 hours at 25°C ±0.005 per cent/°C maximum	±0.02 per cent for 24 hours at 25°C ±0.005 per cent/°C maximum
TOTAL HARMONIC DISTORTION:	0.1 per cent maximum	0.1 per cent maximum	0.1 per cent maximum

Specifications (Continued)

EXTERNAL SYNCHRONIZATION:	A 5 volt rms signal within ±0.5 per cent of oscillator frequency is required to acquire "lock". All specifications apply with external synchronization, however, re-adjustment of the phase shift circuit on multi-phase versions may be required if the natural frequency is pulled greater than 0.1 per cent.
INPUT POWER:	±25 volts DC at approximately ±40 milliamperes available from power amplifier.
OPERATING TEMPERATURE RANGE:	0 to 55°C for all versions.
DIMENSIONS:	3 1/2" high x 8" wide x 7" deep for mounting in a Behlman solid state Invertron®.
FRONT PANEL FINISH:	Grey 26440, Federal Standard 595.

* Model 810T-Freq-Tol-1φ-VAC will provide 0.01 per cent system line and load regulation when used with any Behlman single phase solid state Invertron®. Customer must supply desired output voltage from Invertron® as well as desired output frequency.

Model 810T-Freq-Tol-1φ-105/135VAC will provide 0.01 per cent system line and load regulation when used with any Behlman single phase solid state Invertron®. Ten turn front panel control allows the output voltage of the Invertron® to be adjusted to within 0.01 per cent over the range from 105 to 135 volts.

Model 810T-Freq-Tol-1φ-110/120VAC will provide 0.01 per cent system line and load regulation when used with any Behlman single phase solid state Invertron®. Ten turn front panel control allows the output voltage of the Invertron® to be adjusted to within 0.01 per cent over the range from 110 to 120 volts.

** Model 810T-Freq-Tol-3φD will provide a three phase output when used with two power amplifiers connected in the open delta configuration.

*** Model 810T oscillators may be crystal controlled to 0.01% frequency accuracy on special order if desired.

GENERAL DESCRIPTION

1.1 INTRODUCTION

This instruction manual contains information on the installation, operation, calibration and maintenance of the Behlman 810T Series Precision Oscillators. A detailed theory of operation is provided as an aid to maintenance personnel. A complete parts listing, schematics and component location drawings are also supplied.

1.2 MODEL NUMBER DESCRIPTION

All oscillators in the 810T Series have a four or five place model number which describes the following features: the oscillator series, the output frequency of the oscillator, the frequency tolerance of the oscillator, and the number of phases of the oscillator. In addition, a "D" is placed after the model number if the oscillator is to be used in the three phase, open delta configuration. Also in applications where 0.01 per cent amplitude stability is required from the output of the power source, the required power source output voltage is specified as a part of the oscillator model number. The following examples illustrate this numbering system.

Example 1: 810T-400-0.1-3ϕ

This is a 400 Hz, three phase oscillator with a specified frequency accuracy of ±0.1%.

Example 2: 810T-50-0.1-3ϕD

This is a 50 Hz, three phase oscillator for use in the open delta configuration with a specified frequency accuracy of ±0.1%.

Example 3: 810T-1000-0.1-1ϕ-115V

This is a 1000 Hz, ±0.1 per cent, single phase oscillator which employs a servo feedback loop to regulate the output of the power source to precisely 115.0 volts AC.

1.3 GENERAL DESCRIPTION

The Behlman Model 810T-Freq-Tol-1ϕ Oscillator is a Precision Single Phase Oscillator which provides precisely 5.00 volts rms output at a single fixed frequency in the range from 45 Hz to 10 KHz. A servo feedback loop, which is referenced to a precision zener diode, is used to control the output of this precision oscillator.

If desired, the oscillator servo feedback voltage may be taken from the output of the associated power amplifier rather than the output of the oscillator. In this case, the complete single phase power source will provide a precision signal of fixed amplitude and frequency. In this application, a special coupling transformer is used to sense the desired output voltage of the power source and transform it to the required servo feedback voltage (5.00 volts rms).

The Behlman Model 810T-Freq-Tol-2ϕ Oscillator is a two phase oscillator which provides a zero to 5 volt rms output as controlled by a ten-turn front panel mounted potentiometer. The output of the servo controlled single phase oscillator is used to drive a single phase to two phase convertor.

The Behlman Model 810T-Freq-Tol-3ϕ Oscillator is a three phase oscillator which provides a zero to 5 volt rms output as controlled by a ten-turn front panel mounted potentiometer. The output of the servo controlled single phase oscillator is used to drive a single phase to three phase convertor.

1.4 ACCESSORY EQUIPMENT

The following equipment is available for use with the 810T Series Precision Oscillators.

1.4.1 4800-703 Extender Assy. This assembly allows the oscillator to be tested and adjusted outside of the associated power amplifier.

CAUTION

HIGH VOLTAGE (115 AC)

Voltages up to 500 VAC are available in certain associated Invertrons®. This equipment generates potentially lethal voltages.

DEATH

on contact may result if personnel fail to observe safety precautions. Do not touch electronic circuits when power is applied. Avoid contact with connector pins C and D of the plug-in oscillator, the primary power circuits, and output circuits of the associated Invertron if oscillator is tested and adjusted with Invertron®.

INSTALLATION AND OPERATION

2.1 UNPACKING

Individual oscillators are shipped in a cardboard container with protective inner packing. Do not destroy this packing container until the unit has been inspected for possible damage in shipment.

2.2 POWER REQUIREMENTS

The Behlman 810T Series Precision Oscillators operate from plus (+) and minus (-) 25 volts DC at 0.040 amperes. This power is normally obtained from the associated power amplifier.

2.3 FUSE REQUIREMENTS

No separate fuse is required with the Behlman 810T Series Precision Oscillators.

2.4 ACCEPTANCE TEST PROCEDURE

Inspect the unit for any possible shipping damage immediately upon receipt. If damage is evident, notify the carrier. DO NOT return an instrument to the factory without prior approval. If the unit appears in good condition, perform the following:

Mount the oscillator in the appropriate rack housing or otherwise apply ±25 volt DC power to the unit.

2.4.1 MODEL 810T-Freq-Tol-1ϕ FIXED FREQUENCY OSCILLATOR

The output of this single phase oscillator should be 5.000 volts rms ±5 millivolts. Potentiometer A1R38 located at the rear of the oscillator may be adjusted if required. Connect an oscilloscope to the output of the oscillator and check that the oscillator has a clean sine wave output with no clipping or other distortion. Check that the output frequency is within 0.1 per cent of that indicated in the manual addendum. Detailed test procedures are given in the TEST PROCEDURE of this manual if further evaluation of the oscillator is required at this time.

2.4.2 MODEL 810T-Freq-Tol-1ϕ-VAC

This oscillator must be tested with the appropriate power source. Connect an oscilloscope to the output of the power source and check that the output of the power source is a clean sine wave with no clipping or other distortion. If problems are encountered follow the procedure given in Section 4.6 of this instruction manual.

2.4.3 MODEL 810T-Freq-Tol-3ϕ FIXED FREQUENCY OSCILLATOR

The output of this three phase oscillator is controlled by the front panel AMPLITUDE control. Rotate this control fully clockwise. The output amplitude of each phase of the oscillator should be at least 5 volts rms. See Figure 5 for detailed test circuit.

Connect an oscilloscope to the output of the oscillator and check that each phase of the oscillator has a clean sine wave output with no clipping or other distortion. Check that the output frequency is within 0.1 per cent of that indicated in the manual addendum. Detailed test procedures are given in the TEST PROCEDURE of this manual if further evaluation of the oscillator is required at this time.

2.4.4 MODEL 810T-Freq-Tol-2ϕ FIXED FREQUENCY OSCILLATOR

The output of this two phase oscillator is controlled by the front panel AMPLITUDE control Rotate this control fully clockwise. The output amplitude of each phase of the oscillator should be at least 5 volts rms. See Figure 5 for detailed test circuit.

Connect the oscilloscope to the output of the oscillator and check that both phases of the oscillator have a clean sine wave output with no clipping or other distortion. Check that the output frequency is within 0.1 per cent of that indicated in the manual addendum. Detailed test procedures are given in the TEST PROCEDURE of this manual if further evaluation of the oscillator is required at this time.

2.5 MECHANICAL INSTALLATION AND WIRING

The 810T Series Precision Oscillators fit directly into the Behlman Solid State Invertron Series of power amplifiers. All power for the oscillator, as well as signal output, is coupled through the printed circuit connector at the rear of the oscillator. The following table lists the voltage and applicable connector pins.

Pin	Function	
1	Output singal low	Phase A
2	Output signal high	
3	Power Ground	
4	+25 volt input	
5	-25 volt input	
6	Output signal low	Phase B
7	Output signal high	
8	Output signal low	Phase C
9	Output signal high	
10	External sync input	
H	Servo feedback low	From output of power source
J	Servo feedback high	
C	115 volt AC line input	
D	115 volt AC line input	

The single phase version of the 810T Series Oscillator only has an "A" phase output. The two phase version of the 810T Series Oscillator has an "A" and "C" phase output while the three phase version of this oscillator has all three outputs.

The servo feedback circuit is used for high stability fixed output voltage requirements. Oscillators which incorporate this feature are specified in the manner given in Section 1.2 of this instruction manual.

The 115 volt AC input terminals are only used with crystal controlled versions of this oscillator.

2.6 OPERATING CONTROLS

Single phase versions of the 810T oscillator have no front panel operating controls with the exception of the Model 810T-Freq-Tol-1ϕ-105/135VAC. Multiphase versions of this oscillator have an AMPLITUDE control which is used to vary the output voltage level of all phases of the oscillator from 0 volts to greater than 5.0 volts rms.

In a multiphase power source, the GAIN control on each of the associated power amplifiers is used as a trim control to adjust each of the output leg voltages so that they are precisely equal to each other.

CAUTION

REMOVE POWER FROM BEHLMAN SOLID STATE INVERTRON® BEFORE REMOVING OR INSERTING PLUG-IN OSCILLATOR.

THEORY OF OPERATION

3.1 GENERAL

The Behlman 810T Series Precision Oscillators provide a very high degree of amplitude stability. This amplitude stability is determined by a servo feedback loop which is referenced to a precision zener diode. The multiphase oscillators in this series employ a single phase to multiphase converter circuit to obtain two phase and three phase outputs.

3.2 MODEL 810T-Freq-Tol-1ϕ

A block diagram for the basic single phase oscillator is shown in Figure 2. The Wien bridge oscillator generates a sine wave signal at the output frequency. This sine wave output is used to drive a mosfet modulator. The sine wave output of this modulator is used to drive an active band pass filter which is tuned to the frequency of the Wien bridge oscillator. This filter eliminates harmonic distortion generated in the modulator and in the Wien bridge oscillator from appearing in the output. The output amplifier amplifies the signal to 5 volts rms and provides a low output impedance.

The AC to DC converter is used to obtain a DC signal proportional to the amplitude of the output signal. The difference between the output of the AC to DC converter and the DC reference is used to drive an error integrator. The output of this error integrator is used to drive the gate of the mosfet. Therefore, any change in the output amplitude of the Wien bridge oscillator is compensated by a corresponding change in the gain of the mosfet modulator circuit.

3.2.1 DETAILED CIRCUIT OPERATION

A schematic diagram for the single phase oscillator is shown in drawing 4810-070 and all components of this oscillator are mounted on the printed circuit board. This printed circuit board is designated as the A1 assembly.

3.2.1.1 WIEN BRIDGE OSCILLATOR

The Wien bridge oscillator consists of integrated circuit A1IC1 and associated components. Capacitors A1C5, A1C6 and resistor A1R8 provide the required high frequency roll-off to stabilize integrated circuit A1IC1. The negative feedback loop, consisting of A1R3, A1R9, A1R10, A1CR1, A1CR2, A1CR5 and A1CR6, is used to set the closed loop gain of A1IC1 to 3.0. Resistor A1R9 is set at the factory for an output of 3.0 volts to 4 volts rms at pin 6 of A1IC1. The frequency of the Wien bridge oscillator is set by A1R1, A1R2, A1C1, A1C2, A1C3, A1C4, A1C37 and A1C38. Capacitor A1C37 and A1C38 provide temperature compensation of the oscillator frequency.

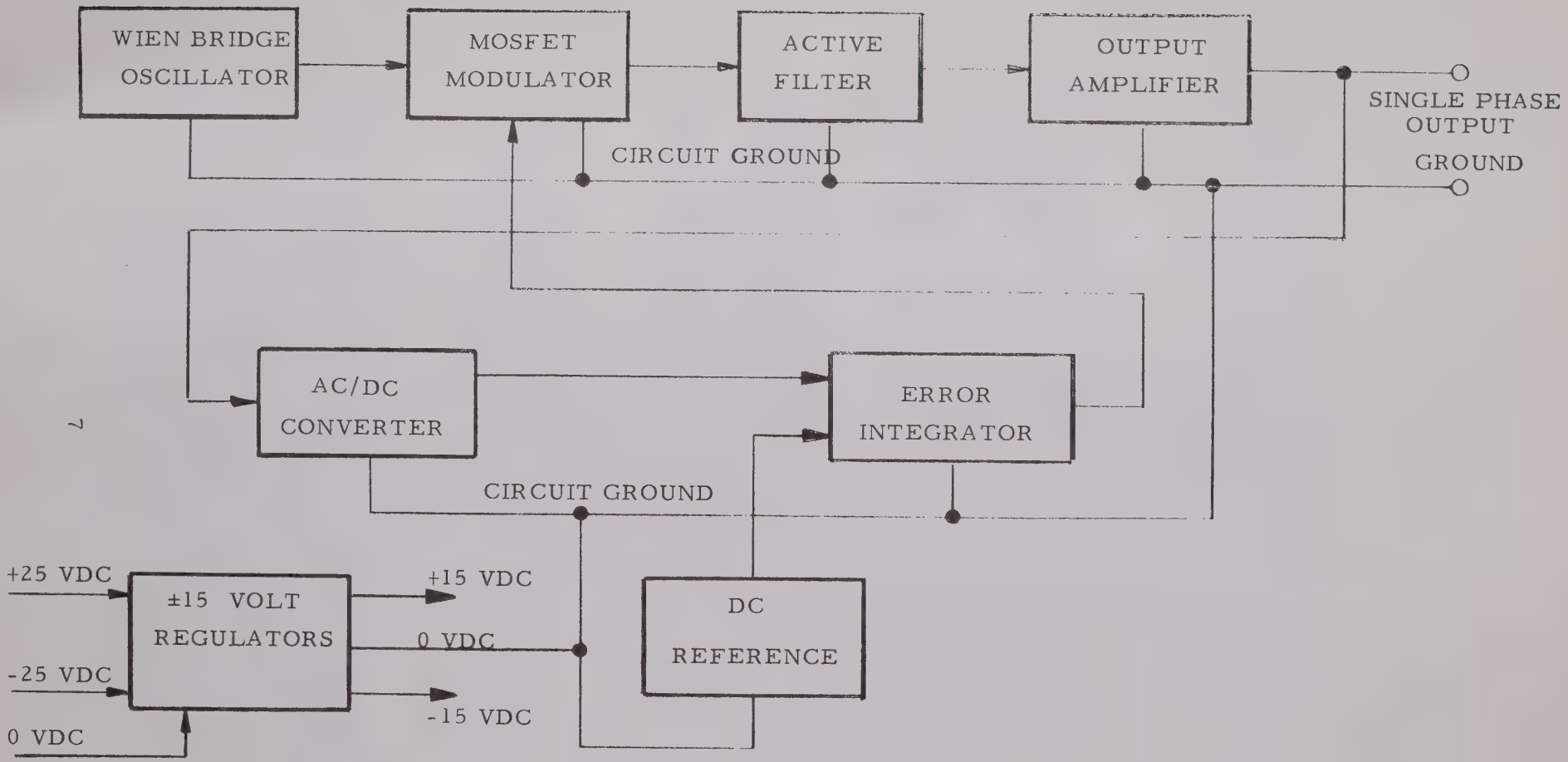


FIGURE 2. Block Diagram for Series 810T Single Phase Oscillator.

Variable capacitor A1C2 is used as a trim capacitor to set the frequency to its exact value. Circuit values on the schematic diagram apply for operation at 400 Hz. The manual addendum, contained in this manual, provides information on all components which change value as a function of the frequency of the oscillator.

A 5.0 volt rms sync signal may be applied to A1R69 if desired. The sync signal should be within ±0.5 per cent of the natural frequency of oscillation and the output frequency of the Wien bridge oscillator should track the external oscillator over this frequency range with the output of A1IC1 remaining between 3.0 and 5.0 volts rms.

3.2.1.2 MOSFET MODULATOR

The mosfet modulator consists of integrated circuit A1IC2, mosfet A1Q3 and associated components. Mosfet A1Q3 is an N-channel depletion type device. As the gate bias becomes more negative, the drain to source resistance of the device increases allowing less of the sine wave signal to be coupled to the input of A1IC2. Resistor A1R16 is set at the factory so that the gain of the mosfet modulator is approximately one with 0 to -3 volts bias on the gate of A1Q3. In order to reduce the distortion generated in the mosfet, the signal level into the mosfet is quite small, approximately 20 millivolts rms.

3.2.1.3 BANDPASS FILTER

The bandpass filter consists of integrated circuit A1IC4 and associated components. Capacitors A1C14, A1C15 and resistor A1R28 provide the required high frequency roll-off to stabilize integrated circuit A1IC4. This integrated circuit is connected to operate as a current inverting negative impedance converter (INIC). Potentiometer A1R30 is used to adjust the "Q" of the bandpass filter and should be set so that the gain of the bandpass filter is 20 at the oscillator output frequency. The output impedance of the bandpass filter is fairly high (pin 3 of A1IC4) so care should be taken to avoid loading this point during check out of this circuitry.

3.2.1.4 OUTPUT AMPLIFIER

The output amplifier consists of integrated circuit A1IC6 and associated components. Capacitors A1C18, A1C19 and resistor A1R40 provide the required high frequency roll-off to stabilize integrated circuit A1IC6. This integrated circuit is connected to a potentiometric type feedback loop which provides a high input impedance and a low output impedance. The closed loop gain of this stage is determined by A1R34 and A1R36 and is slightly less than 13. The 5.0 volt rms output

of this stage is used to drive the Phase "A" output in the case of the single phase oscillator and is used to drive the single phase to multiphase converter in the case of the two phase or three phase oscillator.

3.2.1.5 AC-DC CONVERTER

The AC-DC converter consists of integrated circuit A1IC3, A1IC5 and associated components. Capacitors A1C10, A1C11 and resistor A1R18 provide the required high frequency roll-off to stabilize integrated circuit A1IC3. Capacitors A1C16, A1C17 and resistor A1R29 provide the required high frequency roll-off to stabilize integrated circuit A1IC5. The output of A1IC3, taken from the junction of A1CR8 and A1R22, is a negative going half-wave rectified sine wave. This output from A1IC3 is applied to the inverting input of A1IC5 through resistor A1R23 where it is added to the signal input obtained through resistor A1R21. Integrated circuit A1IC5 provides a rectified sine wave output (at pin 6 of A1IC5) such that the average value of the rectified sine wave output is almost equal to the rms value of the signal across capacitor A1C21. These two signals should be within ±0.2 per cent of each other when measured in the above fashion.

3.2.1.6 DC REFERENCE

The DC reference consists of transistor A1Q4, zener diode A1CR10, and associated components. Transistor A1Q4 is connected as a constant current source and supplies 8 milliamperes DC for driving the zener reference diode A1CR10 and the voltage divider A1R37, A1R38, and A1R39. Zener reference diode A1CR10 has a temperature coefficient of less than ±10 ppm per degree centigrade and is used to provide a stable voltage into the error integrator.

In the case of the single phase oscillator, A1R38 is adjusted so that the output voltage of the single phase oscillator is exactly 5.00 volts rms. For multiphase applications, this adjustment is not significant and it is merely adjusted so that the output of the multiphase converter can be set from zero to greater than 5 volts rms with the front panel AMPLITUDE control.

3.2.1.7 ERROR INTEGRATOR

The error integrator consists of dual transistor A1Q5, integrated circuit A1IC7 and associated components. Capacitors A1C22, A1C23 and resistor A1R45 provide the required high frequency roll-off to stabilize integrated circuit A1IC7. Transistor A1Q5 is connected as a differential emitter follower and provides a high input impedance to the error integrator.

The integrated circuit A1IC7 provides the semi-infinite gain required for proper operation of the integrator. Capacitor A1C24 is used as the integrating capacitor. If the average value of the rectified sine wave at the output of the AC-DC converter is greater than the reference voltage at the arm of potentiometer A1R38, then the output of the integrator tends to swing negative. This, in turn, drives the gate of the mos-fet modulator negative which reduces the gain of the modulator and reduces the sine wave signal at the output of the modulator. As a result, the signal is reduced at the output of A1IC6 and at the output of the AC-DC converter.

3.2.1.8 POWER SUPPLY REGULATORS

The power supply regulators allow the oscillator to operate from the unregulated ±25 volt DC power supply in all Behlman solid state Invertron® power sources. The oscillator requires approximately ±40 milliamperes with less than 3 volts of peak-to-peak ripple at the input to the regulator. The output of the regulators is ±15.5 volts ±5 per cent with less than 15 millivolts peak-to-peak ripple.

3.3 MODEL 810T-Freq-Tol-1ϕ-VAC

This version of the 810T Series Oscillator allows the servo feedback voltage to be taken from the output of the power source. This signal, from the output of the power source, is coupled through an appropriate coupling transformer to the input of the AC to DC converter. The secondary of this coupling transformer should supply a 5.0 volt rms signal to the AC to DC converter. The primary of the coupling transformer may be tied directly to the load if external sensing is required.

3.4 MODEL 810T-Freq-Tol-3ϕ

This version of the 810T Series Oscillator uses the basic Wien bridge oscillator circuit and the servo control circuit described in Section 3.2 of this manual. The output of this single phase oscillator is used to drive a single phase to three phase converter. A block diagram for this single phase to three phase converter is shown in Figure 3. The output signal from the single phase oscillator is applied to the front panel AMPLITUDE control so that the output of all three phases may be varied in a simultaneous manner.

3.4.1 DETAILED CIRCUIT DESCRIPTION

A schematic diagram for the single phase to three phase conveter is shown in drawing D4810-070, sheet 2. All components in this section of the oscillator are also mounted on the printed circuit board with the exception of the AMPLITUDE control. The printed circuit board is designated as the A1 assembly.

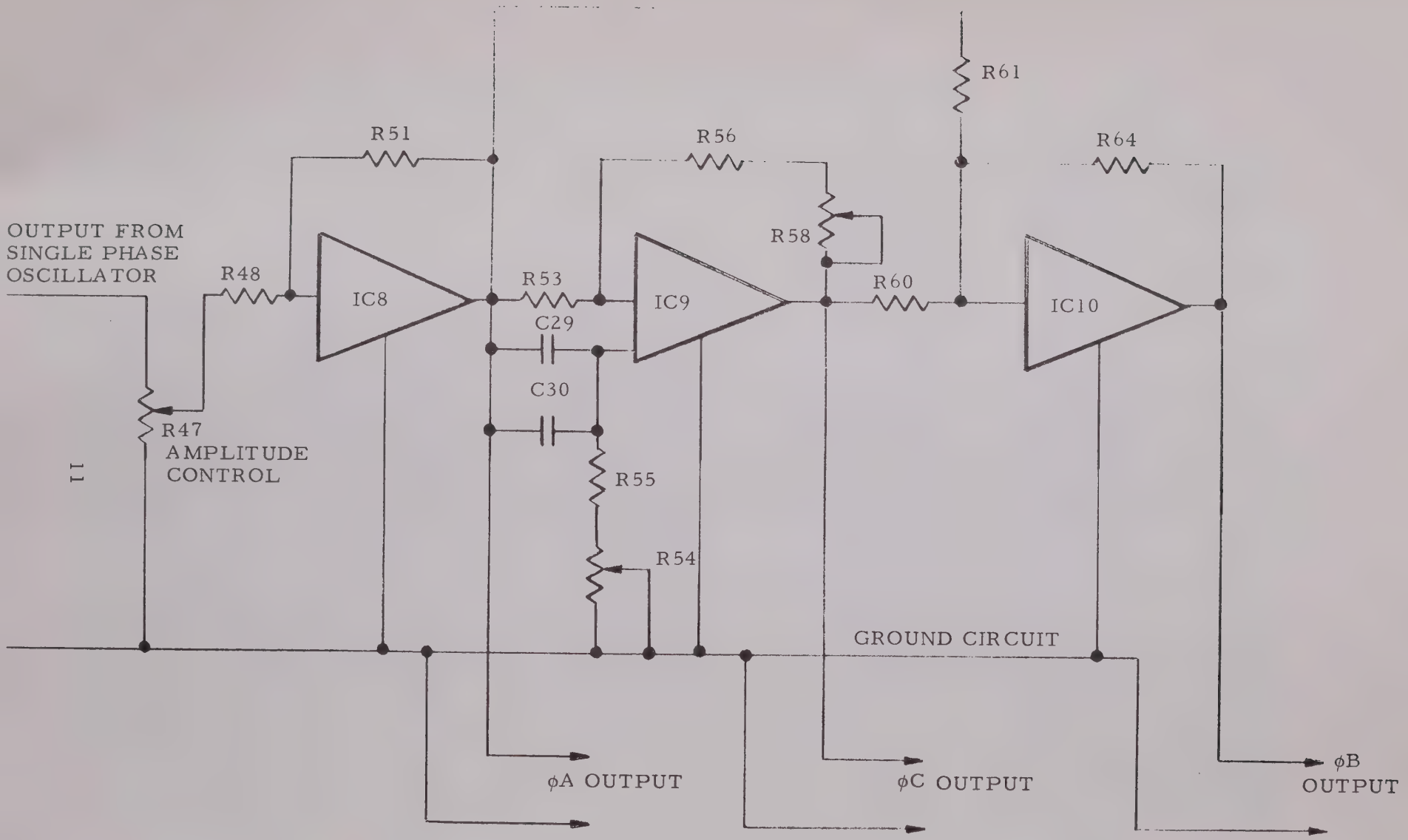


FIGURE 3. Block Diagram for Single Phase to Three Phase Converter.

3.4.1.1 PHASE "A" OUTPUT

Integrated circuit A1IC8 and associated components are used to supply phase "A" output. Integrated circuit A1IC8 is used in the operational configuration and supplied a closed loop gain of -1.0. Capacitors A1C26, A1C27 and resistor A1R50 provide the required high frequency roll-off to stabilize integrated circuit A1IC8.

3.4.1.2 PHASE "C" OUTPUT

Integrated circuit A1IC9 and associated components are connected to form an "all-pass" active filter which provides phase shift but no attenuation of the signal amplitude. Capacitors A1C29, A1C30 and resistors A1R54 and A1R55 control the phase shift of this network. When this lead network is used as shown in Figure 3, the output signal becomes 120 degrees ahead of the phase "A" output and is designated as the phase "C" output.

3.4.1.3 PHASE "B" OUTPUT

Integrated circuit A1IC10 and associated components are used to supply phase "B" output. Phase "B" output is generated by summing the phase "A" and the phase "C" outputs at the input to an operational amplifier, A1IC10. This summing action generates an equivalent minus phase "B" signal which in inverted by A1IC10 to form the phase "B" output. Capacitors A1C34, A1C35 and resistor A1R66 provide the required high frequency roll-off to stabilize integrated circuit A1IC10.

3.5 MODEL 810T-Freq-Tol-2ϕ

This version of the 810T Series Oscillator uses the basic Wien bridge oscillator circuit and the servo control circuit described in Section 3.2 of this manual. The output of this single phase oscillator is used to drive a single phase or two phase converter. A block diagram for this single phase to two phase converter is shown in Figure 4. The output signal from the single phase oscillator is applied to the front panel AMPLITUDE control so that the output of both phases may be varied in a simultaneous manner.

3.5.1 DETAILED CIRCUIT DESCRIPTION

A schematic diagram for the single phase to two phase converter is shown in drawing D4810-070, sheet 2. All components in this section of the oscillator are mounted on the printed circuit board with the exception of the AMPLITUDE control. The printed circuit board is designated as the A1 assembly, the front panel is a part of the top assembly.

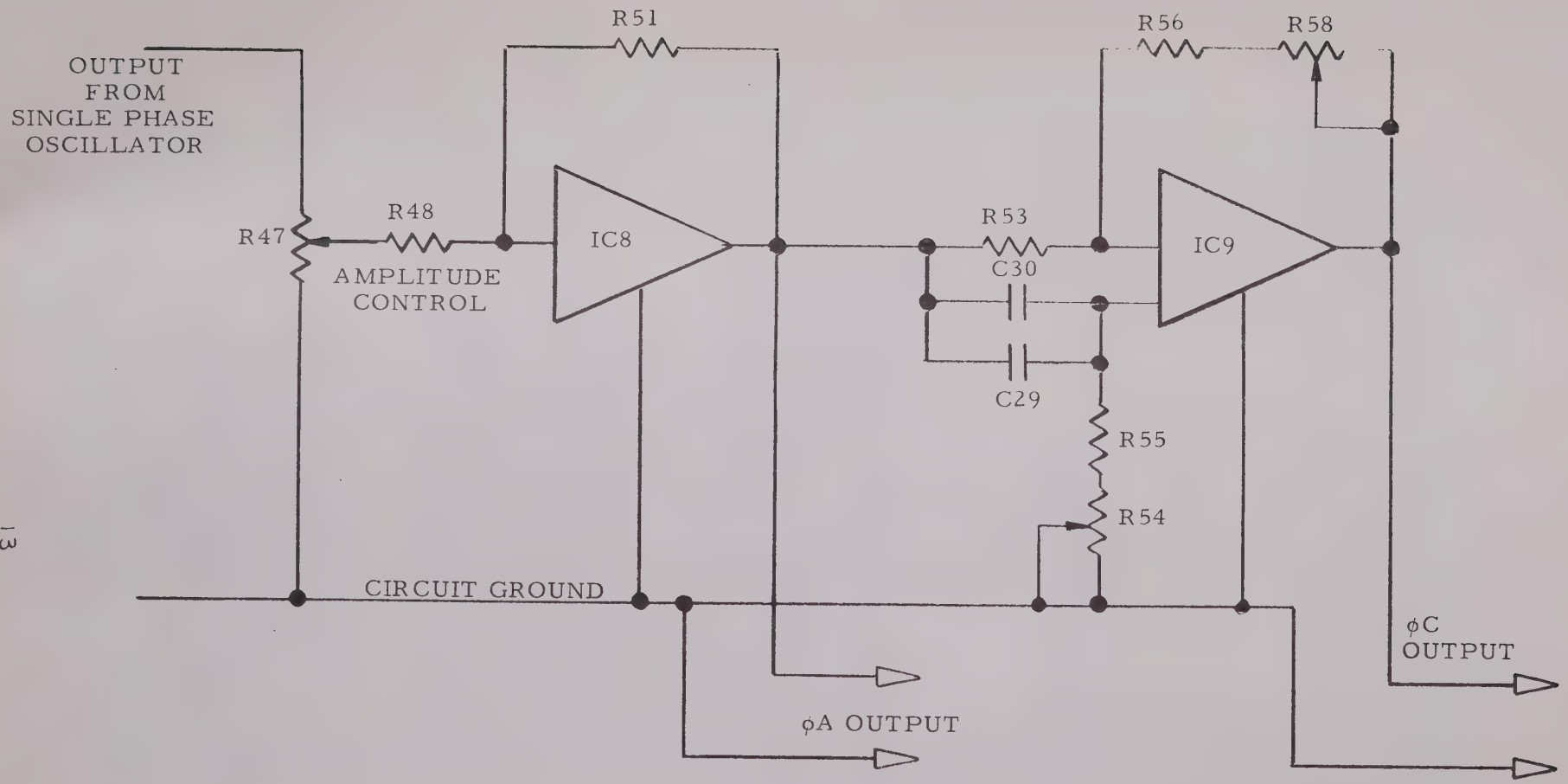


FIGURE 4. Block Diagram for Single Phase to Two Phase Converter.

3.5.1.1 PHASE "A" OUTPUT

Integrated circuit A1IC8 and associated components are used to supply phase "A" output. Integrated circuit A1IC8 is used in the operational configuration and supplies a closed loop gain of -1.0. Capacitors A1C26, A1C27 and resistor A1R50 provide the required high frequency roll-off to stabilize integrated circuit A1IC8.

3.5.1.2 PHASE "C" OUTPUT

Integrated circuit A1IC9 and associated components are connected to form an "all pass" active filter which provides phase shift but not attenuation of the signal amplitude. Capacitors A1C29 and A1C30 and resistors A1R54 and A1R55 control the phase shift of this network. When this lead network is used as shown in Figure 4, the output signal is shifted 90 degrees ahead of the phase "A" output and is designated as the phase "C" output.

CAUTION

HIGH VOLTAGE (115 AC)

Voltages up to 500 VAC are available in certain associated Invertrons®. This equipment generates potentially lethal voltages.

DEATH

on contact may result if personnel fail to observe safety precautions. Do not touch electronic circuits when power is applied. Avoid contact with connector pins C and D of the plug-in oscillator, the primary power circuits, and output circuits of the associated Invertron if oscillator is tested and adjusted with Invertron®.

ADJUSTMENT PROCEDURE

4.1 GENERAL

The following adjustment procedure, or any part of it, may be performed on a routine basis to insure that the oscillator remains within the specified performance limits. This procedure should always be followed after any service to the basic oscillator circuitry.

The adjustment procedure is divided into several sections. These are:

1) Adjustment procedure for Wien bridge oscillator.
2) Adjustment procedure for servo loop.
3) Final adjustment for Model 810T-Freq-Tol-1ϕ.
4) Final adjustment for Model 810T-Freq-Tol-1ϕ-VAC.
5) Final adjustment for Model 810T-Freq-Tol-3ϕ.
6) Final adjustment for Model 810T-Freq-Tol-3ϕD.
7) Final adjustment for Model 810T-Freq-Tol-2ϕ.

4.2 TEST EQUIPMENT

The following test equipment is required to perform the adjustment procedure.

a) Oscilloscope, Tektronix 531A with general purpose plug-in or equivalent.
b) Behlman Power Source or two H.P. 721A DC Power Supplies or equivalent.
c) Distortion Analyzer, H.P. H02-330B or equivalent.
d) Differential Voltmeter, Fluke 883A or equivalent.
e) Frequency Meter, H.P. 523 CR or equivalent.
f) Oscillator, H.P. 200CD or equivalent.

4.3 ADJUSTMENT PROCEDURE FOR WIEN BRIDGE OSCILLATOR

Connect the precision oscillator as shown in Figure 5 using either the ±25 volt power supply in the Behlman power amplifier or a pair of external +25 volt and -25 volt DC power supplies. Each power supply should draw from 30 to 40 milliamperes. Allow the unit to warm up for one half hour.

4.3.1 After determining the basic frequency and frequency accuracy of the oscillator from the manual addendum, set the basic Wein bridge oscillator frequency with trimmer capacitor A1C2. The frequency may be monitored with the counter at either integrated circuit A1IC1 pin 6 or at the phase "A" output. The trimmer capacitor A1C2 has sufficient resolution to allow the frequency to be set within .02 per cent.

4.3.2 Measure the output amplitude and distortion of the Wein bridge oscillator at A1IC1 pin 6 with the differential voltmeter and distortion analyzer. The output amplitude should be between 3.0 volts and 4 volts rms. The distortion should be between 0.25 per cent and 0.7 per cent. Resistor A1R9 and capacitor A1C3 may be changed, if required. Any change in these components will require that step 4.3.1 be repeated.

4.3.3 Connect a sine wave oscillator to the external sync input of the Model 810T oscillator (either at pin 10 of the A1 printed circuit board or at the external sync input of the power source) and adjust the output of the external oscillator to 5 volts rms. Adjust the output frequency of this external oscillator to the design center frequency of the 810T oscillator. Select resistor A1R69 so that the Wien bridge oscillator formed by A1IC1 can be "pulled" ±0.5 per cent without exceeding a 3.0 volt to 5 volt range at A1IC1 Pin 6 and distortion given in 4.3.2.

4.4 ADJUSTMENT PROCEDURE FOR SERVO LOOP

Connect the precision oscillator as shown in Figure 5 and check that the basic Wien bridge oscillator is operating properly.

4.4.1 Connect the differential voltmeter to the arm of potentiometer A1R38 and measure the DC voltage at this point. In the case of the Model 810T-Freq-Tol-1ϕ oscillator, this DC voltage should be 5.00 volts ±10 millivolts for exactly 5.00 volts rms output across capacitor A1C21. In the case of the two phase or three phase oscillators, this voltage should be above 5.0 volts DC and less than 5.1 volts DC so as to provide 5 volts rms output from all phases with the front panel AMPLITUDE control fully clockwise.

4.4.2 Connect the differential voltmeter to A1IC2 pin 6 and read the AC input to the bandpass filter. Adjust the input to the bandpass filter to 15 millivolts to 20 millivolts rms with potentiometer A1R30. The output of the bandpass filter, A1IC4 pin 3, should remain at 400 to 420 millivolts rms.

4.4.3 Connect the differential voltmeter to the junction of A1R11 and A1R12 and check that the AC input to the mosfet modulator is between 15 millivolts rms and 20 millivolts rms. No adjustment is normally provided for this test, although it is somewhat sensitive to the mosfet gate bias adjustment given in step 4.4.4 below.

4.4.4 Measure the DC output from the error integrator with the differential voltmeter. This DC voltage should be between zero volts and -3 volts DC. This voltage may be adjusted by changing the value of resistor A1R16. If the mosfet is replaced, then resistor A1R16 may have to be replaced also in order to bring the gate bias back to the proper region. The output distortion is also somewhat sensitive to the gate bias and is generally a minimum value with approximately -1 volts gate bias.

4.5 FINAL ADJUSTMENTS FOR MODEL 810T-Freq-Tol-1ϕ

The output voltage of the Model 810T-Freq-Tol-1ϕ oscillator should be measured with the differential voltmeter connected to the phase "A" output (pin 1 and pin 2 of the printed circuit connector). This voltage should be adjusted to exactly 5.000 volts rms ±1 millivolt with potentiometer A1R38.

4.6 FINAL ADJUSTMENT FOR MODEL 810T-Freq-Tol-1ϕ-VAC

4.6.1 Connect a differential voltmeter to the output of the power source and check that the power source has a clean sine wave output. If problems are encountered, check that the power source is on the correct range and that the servo feedback coupling transformer has the correct turns ratio for the specified system output voltage. Check that the GAIN control is set so that pin 6 of A1IC7 is biased to approximately -2 volts DC (usually about 75% of the way clockwise). All servo loop biases should correspond to those given in Section 4.4.2 through 4.4.4 of this procedure.

4.6.2 Adjust potentiometer A1R38 so that the output of the power source is exactly equal to value specified for the system.

4.6.3 Check that the system meets line and load regulations specifications.

4.7 FINAL ADJUSTMENTS FOR MODEL 810T-Freq-Tol-3ϕ

Set the front panel AMPLITUDE control so that the output of phase "A" (pin 2 of the printed circuit connector) is exactly 5.000 volts rms ±1 millivolt. Verify that the output frequency is correct with the counter.

4.7.1 Adjust potentiometer A1R58 so that the output of phase "C" is exactly 5.000 volts rms ±1 millivolt. Adjust potentiometer A1R54 so that the phase shift between phase "A" and phase "C" is 120 degrees. These adjustments may interact slightly. One of the most exact ways to measure the phase shift from phase "A" to phase "C" is to connect phase "A" and phase "C" in a series opposed configuration. This is accomplished by tieing the differential voltmeter from the high side of phase "C" to

the high side of phase "A". The sum of these two outputs should be exactly 1.732 times the individual phase output or 8.660 volts rms. If the series opposed sum of these two outputs is not 8.660 volts, then A1R54 should be adjusted slightly in value and A1R58 re-adjusted for 5.000 volts rms output from phase "C", if required.

Repeat this procedure until phase "A" and phase "C" each have 5.000 volts rms output ±1 millivolt and that the series opposed sum of these two outputs is 8.660 volts rms ±2 millivolts. A 0.25 degree error in the phase shift will produce a 10.8 millivolt error in the series opposed sum of the phase "A" and phase "C" outputs provided that each separate phase output is exactly 5.000 volts rms.

4.7.2 After the adjustment of phase "C" has been completed, then adjust potentiometer A1R65 so that the amplitude of phase "B" is also 5.000 volts rms ±1 millivolt.

4.8 FINAL ADJUSTMENT FOR MODEL 810T-Freq-Tol-3φD

Set the front panel AMPLITUDE control so that the output of phase "A" (pin 2 of the printed circuit connector) is exactly 5.000 volts rms ±1 millivolt. Verify that the output frequency is correct with the counter.

4.8.1 Adjust potentiometer A1R54 so that the output of phase "C" is exactly 5.000 volts rms ±1 millivolt. Adjust potentiometer A1R54 so that the phase shift between phase "A" and phase "C" is 60 degrees. These adjustments may interact slightly. One of the most exact ways to measure the phase shift from phase "A" to phase "C" is to connect phase "A" and phase "C" in a series opposed configuration. This is accomplished by tieing the differential voltmeter from the high side of phase "C" to the high side of phase "A". The sum of these two outputs should be exactly equal to the individual phase outputs. If the series opposed sum of these two outputs is not 5.000 volts rms, then A1R54 should be adjusted slightly in value and A1R58 re-adjusted for 5.000 volts rms output from phase "C", if required.

Repeat this procedure until phase "A" and phase "C" each have 5.000 volts rms output ±1 millivolt and that the series opposed sum of these two outputs is 5.000 volts rms ±2 millivolts. A 0.25 degree error in the phase shift will produce an 18.8 millivolt error in the series opposed sum of the phase "A" and phase "C" outputs provided that each separate phase output is exactly 5.000 volts rms.

4.9 FINAL ADJUSTMENTS FOR MODEL 810T-Freq-Tol-2ϕ

Set the front panel AMPLITUDE control so that the output of phase "A" (pin 2 of the printed circuit connector) is exactly 5.000 volts rms ±1 millivolt. Verify that the output frequency is corrected with the counter.

4.9.1 Adjust potentiometer A1R58 so that the output of phase "C" is exactly 5.000 volts rms ±1 millivolt. Adjust potentiometer A1R54 so that the phase shift between phase "A" and phase "C" is 90 degrees. These adjustments may interact slightly. One of the exact ways to measure the phase shift from phase "A" to phase "C" is to connect phase "A" and phase "C" in a series opposed configuration. This is accomplished by tieing the differential voltmeter from the high side of phase "C" to the high side of phase "A". The sum of these two outputs should be exactly 1.414 times the individual phase outputs or 7.070 volts rms. If the series opposed sum of these two outputs is less than 7.070 volts, then A1R54 should be adjusted slightly in value and A1R58 re-adjusted for 5.000 volts rms output from phase "A" and phase "C", if required. Repeat this procedure unitl phase "A" and phase "C" each have 5.000 volts rms output ±1 millivolt and the series opposed sum of these two outputs is 7.070 volts rms ±2 millivolts. A 0.25 degree error in the phase shift will produce a 15 millivolt error in the series opposed sum of the phase "A" and the phase "C" outputs provided that each phase output is exactly 5.000 volts rms.

CAUTION

HIGH VOLTAGE (115 AC)

Voltages up to 500 VAC are available in certain associated Invertrons®. This equipment generates potentially lethal voltages.

DEATH

on contact may result if personnel fail to observe safety precautions. Do not touch electronic circuits when power is applied. Avoid contact with connector pins C and D of the plug-in oscillator, the primary power circuits, and output circuits of the associated Invertron if oscillator is tested and adjusted with Invertron®.

TEST PROCEDURE

5.1 GENERAL

The following test procedure may be performed on a routine basis to insure that the 810T Series Precision Oscillators remain within the specified performance limits. This test procedure is divided into several sections. These are:

1) Output voltage and amplitude stability.
2) Harmonic Distortion.
3) Output Frequency and Frequency Stability.
4) Phase Accuracy and Phase Stability.

5.2 TEST EQUIPMENT REQUIRED

The same test equipment is required for the test procedure as was required for the adjustment procedure as given in Section 4.2 of this manual.

5.3 OUTPUT VOLTAGE AND AMPLITUDE STABILITY

Connect the precision oscillator as shown in Figure 5 and allow the unit to warm up for one hour.

5.3.1 The output of the Model 810T-Freq-Tol-1ϕ Oscillator should be measured with the differential voltmeter connected to the phase "A" output (pin 1 and pin 2 of the printed circuit connector). This voltage should be 5.000 volts rms ±5 millivolts. Record the exact voltage for future reference.

5.3.2 Measure the output voltage of the Model 810T-Freq-Tol-1ϕ Oscillator in 15 minute increments for two hours. The change in output voltage must not exceed ±0.5 millivolts. This test may be continued for 24 hours if required. Maintain the ambient temperature at 25°C for this test.

5.3.3 Increase the ambient temperature to 50°C and allow the unit to stabilize for one hour. The output voltage should change less than 3.12 millivolts rms.

5.3.4 In the case of the Model 810T-Freq-Tol-2ϕ or -3ϕ Oscillators, rotate the front panel AMPLITUDE control clockwise until the output voltage from each phase is approximately equal to 5 volts rms. Each phase should be equal to one another within 5 millivolts rms. Record the exact output voltages from each phase for future reference. Measure the output voltage of each phase and repeat in 15 minute increments for 2 hours. The change in output voltage for each individual phase must not exceed ±1.0 millivolts. This test may be continued for 24 hours if required. Maintain the ambient temperature at 25°C for this test.

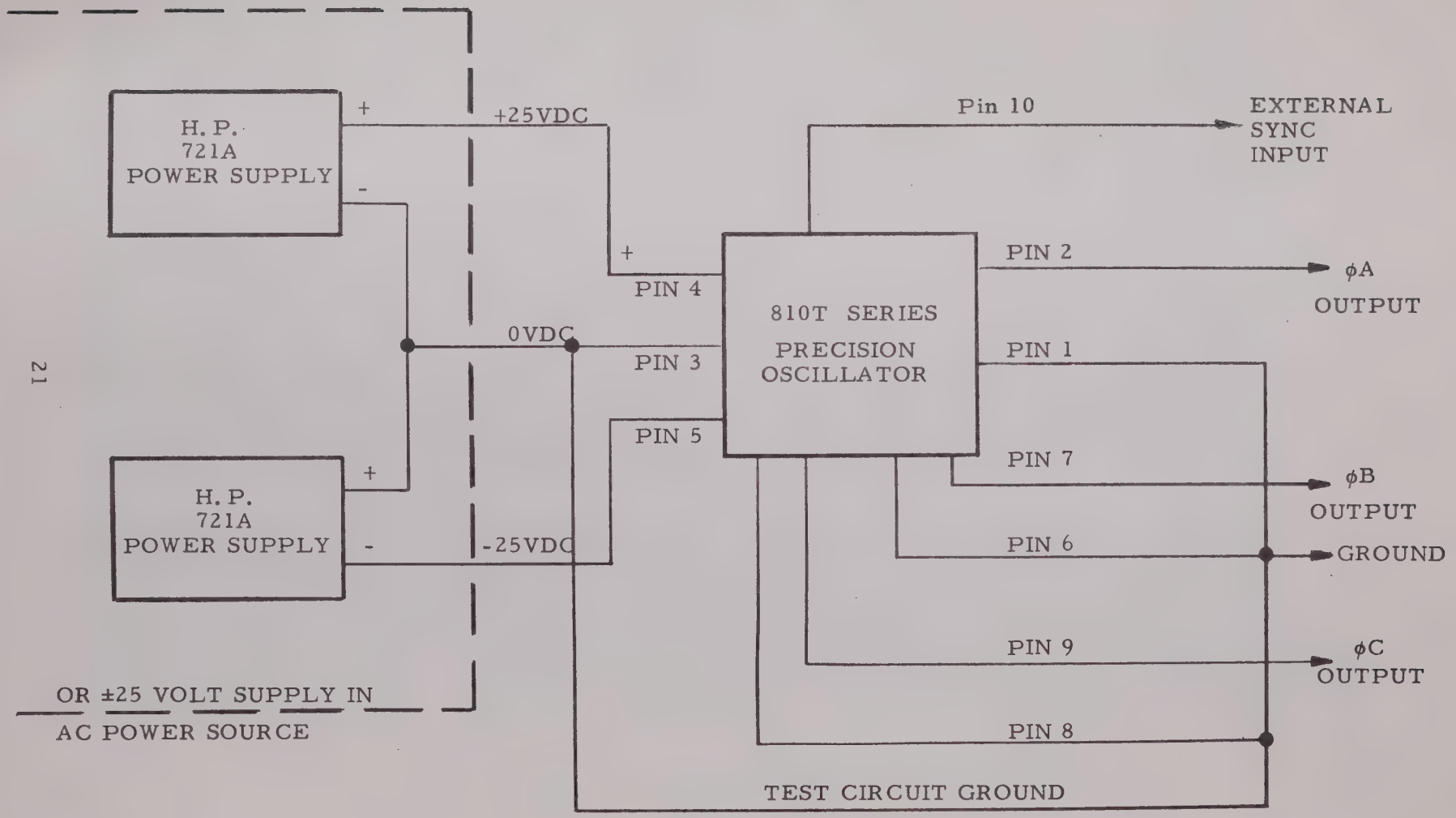


FIGURE 5. Test Circuit for 810T Series Precision Oscillators

5.3.5 Increase the ambient temperature to 50°C and allow the multi-phase oscillator to stabilize for one hour. The output voltage from each phase should change less than 6.25 millivolts rms.

5.4 HARMONIC DISTORTION

Connect the precision oscillator as shown in Figure 5 and allow the unit to warm up for a few minutes. In the case of the multi-phase oscillators, turn the AMPLITUDE control so that the output from each phase is 5.0 volts rms.

5.4.1 Connect the distortion analyzer between the high output of phase "A" and the ground of phase "A". The distortion should be less than 0.1 per cent if the oscillator frequency is between 45 Hz and 5 KHz. If the frequency of the oscillator is above 5 KHz, then the distortion must be below 0.25 per cent.

5.4.2 If the oscillator is a multiphase oscillator, then repeat 5.4.1 for the other ohase or phases. The distortion should not exceed that specified in Section 5.4.1.

5.5 OUTPUT FREQUENCY AND FREQUENCY STABILITY

Connect the unit as shown in Figure 5 and allow the unit to warm up for one hour in a 25°C environment. The output voltage should be approximately 5 volts rms. Adjust the AMPLITUDE control on the multi-phase oscillators, as required.

5.5.1 Measure the phase "A" output frequency at 25°C with the counter. The frequency of the oscillator should be within ±0.1 per cent of that indicated in the manual addendum. Record the frequency for reference in Section 5.5.2. below.

5.5.2 Increase the ambient temperature to 50°C and allow the unit to stabilize for one hour. The output frequency should change less than ±0.25 per cent from that indicated at 25°C.

5.6 PHASE ACCURACY

This section of the manual is only applicable to the multi-phase oscillators. Connect the oscillator as shown in Figure 5 and allow the unit to warm up for one hour in a 25°C environment.

5.6.1 Set the front panel AMPLITUDE control so that the output of phase "A" (pin 1 and pin 2 of the printed circuit connector)is exactly 5.000 volts rms ±1 millivolt with the differential voltmeter.

5.6.2 Measure the output voltage of phase "B" (and phase "C" if applicable) with the differential voltmeter. These voltages should each be 5.000 volts rms ±5 millivolts.

5.6.3 For the Model 810T-Freq-Tol-2ϕ, connect phase "A" and phase "C" in a series opposed configuration (described in section 4.9.1). Measure the series opposed sum voltage with the differential voltmeter. This voltage should be 7.070 volts rms ±15 millivolts.

5.6.4 For the Model 810T-Freq-Tol-3ϕD, connect phase "A" and phase "C" in a series opposed configuration (as described in Section 4.8.1). Measure the series opposed sum voltage with the differential voltmeter. This voltage should be 5.000 volts rms ±18.8 millivolts.

5.6.5 For the Model 810T-Freq-Tol-3ϕ, connect phase "A" and phase "C" in a series opposed configuration (described in Section 4.7.1). Measure the series opposed sum voltage with the differential voltmeter. This voltage should be 8.660 volts rms ±10.8 millivolts.

5.6.6 Repeat step 5.6.5 except connect phase "A" and phase "B" in series opposed configuration. This voltage should also be 8.660 volts rms ±10.8 millivolts.

5.6.7 Repeat step 5.6.5 except connect phase "B" and phase "C" in series opposed configuration. This voltage should also be 8.660 volts rms ±10.8 millivolts.

MAINTENANCE AND TROUBLESHOOTING

6.1 GENERAL

The Behlman 810T Series Precision Oscillators are completely solid state and should provide years of trouble-free service. Since the instrument contains no moving parts, periodic maintenance is limited to cleaning in accordance with good commercial shop practices, and a periodic check of frequency accuracy and distortion at six month intervals. If the oscillator is operated in heavy duty applications where severe temperature extremes or mechanical shock are encountered, it is recommended that a more frequent calibration schedule be established.

6.2 TROUBLESHOOTING

6.2.1 Before attempting to repair the oscillator, check that the controls are properly set, that the DC input power is correct and that an excessive load is not connected to the output of the oscillator. Any load impedance less than 5 K ohm per phase should be considered excessive.

6.2.2 Check that the ±15 volt regulator circuits are operating properly and that they have less than 15 millivolts peak-to-peak ripple.

6.2.3 Check that the basic Wien bridge oscillator is operating satisfactorily. Detailed information on this circuit is given in Section 3.2.1.1 and Section 4.3 in this manual.

6.2.4 Check that the servo feedback loop is operating satisfactorily. Detailed information on this circuitry is given in Section 3.2.1.2 through Section 3.2.1.7 and in Section 4.4 of this manual. If the problem appears to be in this area, disconnect resistor A1R46 at A1IC7 pin 6 and apply a -2 volt DC bias to A1R46. This opens the servo feedback loop and allows servicing of this circuitry by conventional signal tracing methods.

6.2.5 If the problem is in the single phase to multiphase converter, the circuit may be checked by conventional signal tracing methods.

CIRCUIT DIAGRAM

7.1 GENERAL

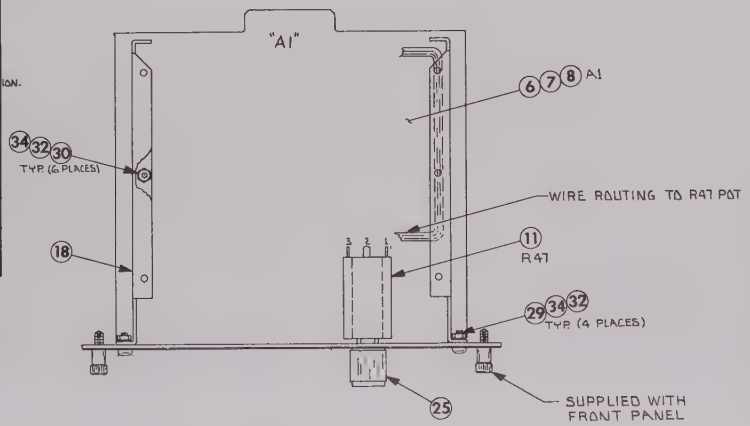
This section contains schematics and mechanical diagrams necessary for operation and maintenance of the 810T Series Precision Multiphase Oscillators. The schematic diagrams illustrate the circuit while the mechanical assemblies indicate the part placement.

7.2 REFERENCE DESIGNATIONS

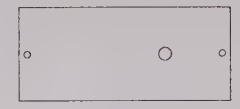
Partial reference designators are shown on schematics and mechanical drawings. Prefix these reference designators with assembly and/or sub-assembly designation for the complete reference designator. For example:

Assembly/Sub-Assembly	Component	Complete Designation
A1	C30	A1C30
None	T1	T1
A3	CR1	A3CR1

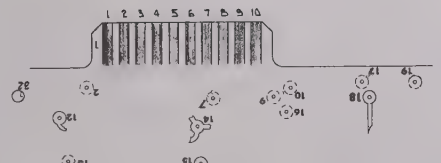
WIRE TAB TABLE SEE DETAIL "A"								
			-3	-2	-1	FROM	TO	WIRE	REMARKS
					X	A1-2	A1-12	#22 AWG	BUSS WIRE, SLEEVED
			X	X		A1-2	A1-18		
			X			A1-7	A1-19		
			X	X		A1-9	A1-17	#22 AWG	BUSS WIRE, SLEEVED
			X	X		R47-2	A1-16	RG179/U	ONE END OF SHIELD TO R47-1, OTHER END TO TIE POINT 15
			X	X		R47-3	A1-13	RG 179/U	ONE END OF SHIELD TO R47-1, OTHER END NO CONNECTION.
			X	X	X	A1-10	A1-20	22	WHT/RED



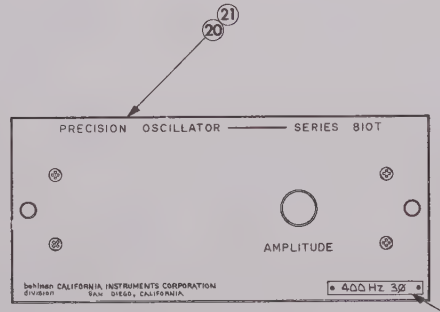
-1 FRONT PANEL (C4810-200-1)
SCALE 1/2



-2 FRONT PANEL (C4810-200-2)
SCALE 1/2



DETAIL "A" PIN & TIE POINT LOCATION
SEE DWG 4810-700 FOR ADDITIONAL TIE POINTS

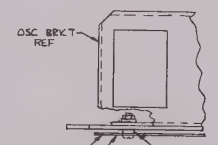


(*) NAME PLATE
(2) (*) DRIVE SCREW
SEE APPLICABLE FREQUENCY & PHASE DETERMINING P/L

-3 ASSEMBLY

-1 & -2 ASSYS ARE THE SAME AS -3 EXCEPT AS SPECIFIED IN P/L & W.T.T.

VIEW FROM SIDE



FOR UNITS WITH 200Hz OR LOWER FREQUENCY SEE NOTE 1

1. INSPECT GROUND CONTINUITY FROM FRONT PANEL CAPTIVE SCREWS TO EACH SIDE RAIL & ON 200 HZ OR LOWER FREQUENCY UNITS CHECK TO GROUND SHIELD.

NOTES: (UNLESS OTHERWISE SPECIFIED)

REVISIONS						
REV	AUTH	DESCRIPTION	ZONE	EFF ON	DATE	APRO

FOR PART LIST SEE SHT 3

ITEM NO	PART NUMBER	PART NAME	MATERIAL — SPECIFICATION	CODE IDENT	FINISH	REF DES.	ZONE
REQD PER ASSY							

DIM IN INCHES TOLERANCES XXX = .010 XX = .03 X° = 30'
BREAK ALL SHARP CORNERS & EDGES MACH SURFACES
DWG SIZE D

EXCEPT AS OTHERWISE PROVIDED BY CONTRACT, THESE DRAWINGS AND SPECIFICATIONS ARE THE PROPERTY OF CALICO AND SHALL NOT BE REPRODUCED OR COPIED OR USED AS THE BASIS FOR THE MANUFACTURE OR SALE OF APPARATUS WITHOUT WRITTEN PERMISSION.

TITLE: PRECISION OSCILLATOR ASSEMBLY

MODEL 810T
RELEASE
CHECKER
DESIGN
DRFTSMN CWEED 4-26-66

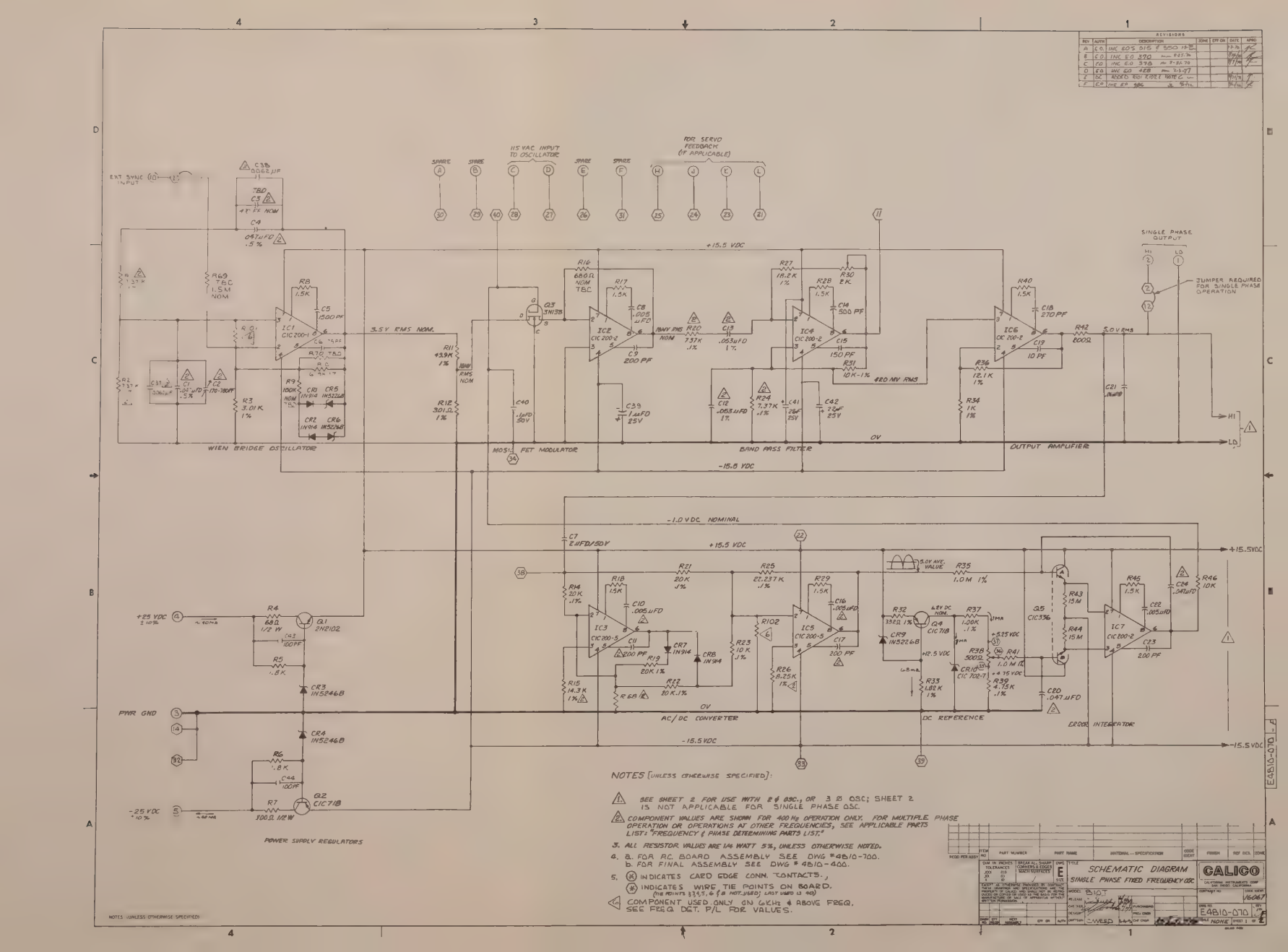
PURCHASING
PROJ ENGR
MFG ENGR

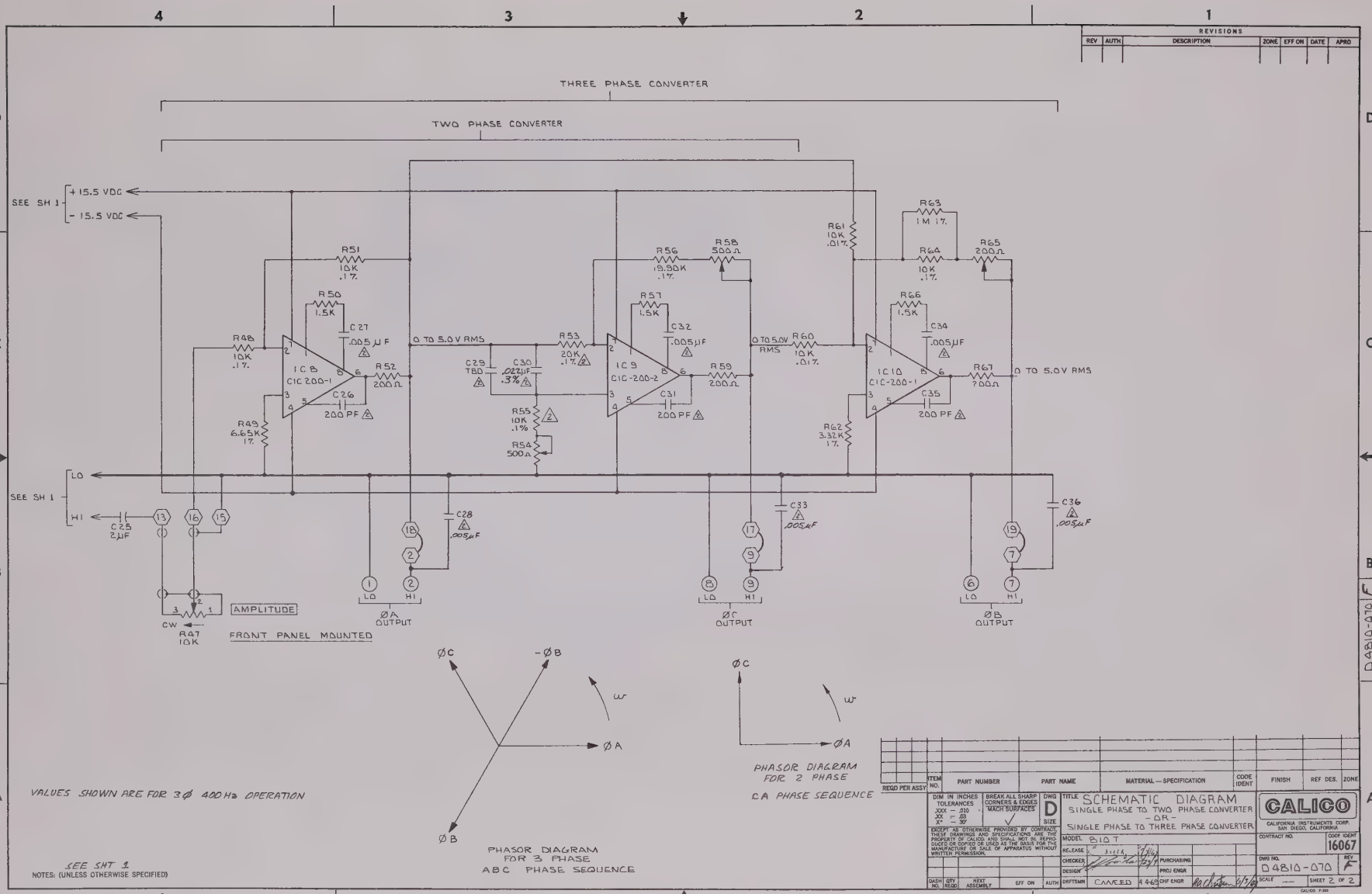
CALICO
CALIFORNIA INSTRUMENTS CORP. SAN DIEGO, CALIFORNIA

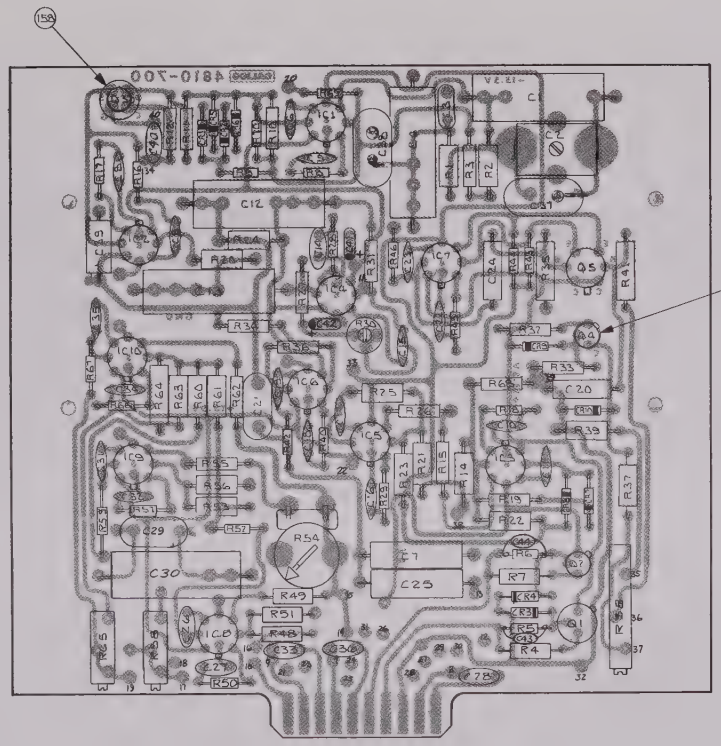
CONTRACT NO.
CODE IDENT 16067
DWG NO. D4810-400
REV B
SCALE 1 SHEET 2 OF 3

DASH NO.	QTY. REQD	NEXT ASSEMBLY	EFF ON	AUTH

D4810-400 B


REVISIONS
REV AUTH DESCRIPTION ZONE ENT OR DATE APPD
A CO INC ECO 515 & 550 12-70
B CO INC ECO 370 11-2-70
C CO INC ECO 376 12-24-70
D EB INC ECO 428 3-13-71
E DC ADDED R101 REMOVE NOTE C 4-14-71
F EB INC ECO 385 8-4-71
115 VAC INPUT TO OSCILLATOR
FOR SERVO FEEDBACK (IF APPLICABLE)
SPARE
EXT. SYNC INPUT
SINGLE PHASE OUTPUT
JUMPER REQUIRED FOR SINGLE PHASE OPERATION
+15.5 VDC
-15.5 VDC
-1.0 VDC NOMINAL
3.5V RMS NOM.
420 MV RMS
5.0V RMS
WIEN BRIDGE OSCILLATOR
MOS FET MODULATOR
BAND PASS FILTER
OUTPUT AMPLIFIER
AC/DC CONVERTER
DC REFERENCE
POWER SUPPLY REGULATORS
PWR GND
NOTES (UNLESS OTHERWISE SPECIFIED):
1. SEE SHEET 2 FOR USE WITH 2 Ø OSC. OR 3 Ø OSC; SHEET 2 IS NOT APPLICABLE FOR SINGLE PHASE OSC.
2. COMPONENT VALUES ARE SHOWN FOR 400 Hz OPERATION ONLY. FOR MULTIPLE PHASE OPERATION OR OPERATIONS AT OTHER FREQUENCIES, SEE APPLICABLE PARTS LIST: "FREQUENCY & PHASE DETERMINING PARTS LIST."
3. ALL RESISTOR VALUES ARE 1/4 WATT 5%, UNLESS OTHERWISE NOTED.
4. a. FOR P.C. BOARD ASSEMBLY SEE DWG #4810-100.
b. FOR FINAL ASSEMBLY SEE DWG # 4810-400.
5. (X) INDICATES CARD EDGE CONN. CONTACTS.,
(X) INDICATES WIRE TIE POINTS ON BOARD. (THE POINTS 3,4,5,6 & 8 NOT USED; LAST USED IS 40)
(LA) COMPONENT USED ONLY ON 6KHz & ABOVE FREQ. SEE FREQ. DET. P/L FOR VALUES.
SCHEMATIC DIAGRAM
SINGLE PHASE FIXED FREQUENCY OSC.
CALICO
MODEL 810T
DWG NO E4810-070
SCALE NONE
E4810-070-F


THREE PHASE CONVERTER
TWO PHASE CONVERTER
SEE SH 1
+15.5 VDC
-15.5 VDC
R51 10K .1%
R50 1.5K
C27 .005µF
R48 10K .1%
IC8 CIC 200-1
R52 200Ω
C26 200 PF
R49 6.65K 1%
0 TO 5.0 V RMS
R53 20K .1%
C29 TBD
C30 .022µF .3%
R55 10K .1%
R54 500Ω
R56 9.90K .1%
R58 500Ω
R57 1.5K
C32 .005µF
IC9 CIC-200-2
R59 200Ω
C31 200 PF
R60 10K .01%
R61 10K .01%
R63 1M 1%
R64 10K .1%
R65 200Ω
R66 1.5K
C34 .005µF
IC10 CIC-200-1
R67 200Ω
C35 200 PF
R62 3.32K 1%
LO
HI
C25 2µF
C28 .005µF
C33 .005µF
C36 .005µF
AMPLITUDE
CW
R47 10K
FRONT PANEL MOUNTED
ØA OUTPUT
ØC OUTPUT
ØB OUTPUT
ØC
-ØB
ØA
ØB
ω
PHASOR DIAGRAM FOR 3 PHASE ABC PHASE SEQUENCE
PHASOR DIAGRAM FOR 2 PHASE CA PHASE SEQUENCE
VALUES SHOWN ARE FOR 3Ø 400 Hz OPERATION
SEE SHT 1
NOTES: (UNLESS OTHERWISE SPECIFIED)
REVISIONS
REV AUTH DESCRIPTION ZONE EFF ON DATE APRD
ITEM NO. PART NUMBER PART NAME MATERIAL — SPECIFICATION CODE IDENT FINISH REF DES. ZONE
REQD PER ASSY
DIM IN INCHES TOLERANCES XXX ± .010 XX ± .03 X° ± 30'
BREAK ALL SHARP CORNERS & EDGES
MACHT SURFACES
DWG SIZE D
EXCEPT AS OTHERWISE PROVIDED BY CONTRACT, THESE DRAWINGS AND SPECIFICATIONS ARE THE PROPERTY OF CALICO AND SHALL NOT BE REPRODUCED OR COPIED OR USED AS THE BASIS FOR THE MANUFACTURE OR SALE OF APPARATUS WITHOUT WRITTEN PERMISSION.
TITLE SCHEMATIC DIAGRAM
SINGLE PHASE TO TWO PHASE CONVERTER
-OR-
SINGLE PHASE TO THREE PHASE CONVERTER
MODEL 810 T
RELEASE
CHECKER
DESIGN
DRFTSMN CAMEO
PURCHASING
PROJ ENGR
CHF ENGR
CALICO
CALIFORNIA INSTRUMENTS CORP. SAN DIEGO, CALIFORNIA
CONTRACT NO.
CODE IDENT 16067
DWG NO. D4810-070
REV F
SCALE —
SHEET 2 OF 2
DASH NO. QTY REQD NEXT ASSEMBLY EFF ON AUTH
D4810-070 F



-3
THREE PHASE

REVISIONS						
REV	AUTH	DESCRIPTION	ZONE	EFF ON	DATE	APRD

ITEM NO.	PART NUMBER	PART NAME	MATERIAL -- SPECIFICATION	CODE IDENT	FINISH	REF. DES.	ZONE
REQD PER ASSY	PL4810-700	PARTS LIST SEE SHEETS 6 THRU —					

DIM IN INCHES TOLERANCES .XXX = .010, .XX = .03, .X = .30
BREAK ALL SHARP CORNERS & EDGES MACH SURFACES ✓
DWG SIZE D

EXCEPT AS OTHERWISE PROVIDED BY CONTRACT, THESE DRAWINGS AND SPECIFICATIONS ARE THE PROPERTY OF CALICO AND SHALL NOT BE REPRODUCED OR COPIED OR USED AS THE BASIS FOR THE MANUFACTURE OR SALE OF APPARATUS WITHOUT WRITTEN PERMISSION.

TITLE: OSCILLATOR P.C. BOARD ASSEMBLY
THREE PHASE

MODEL 810T
RELEASE
CHECKER — PURCHASING
DESIGN — PROJ ENGR
DFTSMN CAWEED — CHF ENGR

CALICO
CALIFORNIA INSTRUMENTS CORP
SAN DIEGO, CALIFORNIA

CONTRACT NO. — CODE IDENT 16067
DWG NO. D4810-700 — REV 8
SCALE 2:1 — SHEET 4 OF —

DASH NO.	QTY REQD	NEXT ASSEMBLY	EFF ON	AUTH
-1	1	D4810-000		

1. FOR SCHEMATIC DIAGRAM SEE DWG 4810-070 SHEET 1 & 2

NOTES: (UNLESS OTHERWISE SPECIFIED)

D4810-700 9

REPLACEABLE PARTS

8.1 GENERAL

This section contains ordering information and complete list of replaceable parts. Parts are listed by major assembly in alphanumeric order of their reference designators. Description, manufacturers' part number, manufacturers' code ident numbers (see Appendix A for list of manufacturers), and CALICO's stock numbers are indicated.

8.2 ORDERING INFORMATION

In order to provide our customers with prompt service on replacement parts, please provide the following information, when applicable, for each part ordered:

a) Model number and serial number of the instrument

b) CALICO part number of the sub-assembly where component is located

c) Component reference designator

d) Component description

e) Component manufacturer number and code ident

f) CALICO stock number.

All replacement parts orders should be placed with CALIFORNIA INSTRUMENTS COMPANY, a division of Aiken Industries, San Diego, California 92111.

CALICO — CALIFORNIA INSTRUMENTS CORP., SAN DIEGO, CALIFORNIA

CODE IDENT 16067

PARTS LIST

REF. DES.	MFG. NUMBER	DESCRIPTION	CODE IDENT	CALICO STOCK NUMBER	ITEM NO.
	D4810-400-1	MODEL 810T SINGLE PHASE	16067		1
	D4810-400-2	MODEL 810T TWO PHASE	16067		2
	D4810-400-3	MODEL 810T THREE PHASE	16067		3
					4
					5
A1	D4810-700-1	PC BD. ASSY - Single Phase	16067		6
A1	D4810-700-2	PC BD. ASSY - Two Phase	16067		7
A1	D4810-700-3	PC BD. ASSY - Three Phase	16067		8
	APPLICABLE FREQUENCY and PHASE DETERMINING PARTS LIST				9
					10
R47	TYPE 62JA	POT 10 K	12697	5-75019	11
					12
					13
					14
					15
					16
					17
	C4810-201-7	PLUG-IN FRAME	16067	1-60001	18
					19
	C4810-200-1	FRONT PANEL - Single Phase	16067	1-60002	20
	C4810-200-2	FRONT PANEL - Two or Three Phase	16067	1-60003	21
					22
					23
					24
	PS-70-2 BLK	KNOB-BLACK	21604	2-40233	25
					26
					27
					28
	4-40 X 3/8 LG.	SCREW Pan Head-Nickle Plated			29
	4-40 - 1/4 LG.	SCREW Pan Head			30
					31
	#4	WASHER INT. STAR			32
					33
	4-40	NUT, HEX			34
					35
					36

MODEL 810T | CALICO P'N 4810-400 | ASSY R.O.

TITLE OSCILLATOR ASSEMBLY | SHT 3 OF 3

CALICO | CALIFORNIA INSTRUMENTS CORP. SAN DIEGO, CALIFORNIA | CODE IDENT 16067 | **PARTS LIST**

REF. DES.	MFG. NUMBER	DESCRIPTION	CODE IDENT	CALICO STOCK NUMBER	ITEM NO.
	4810-700-1	MODEL 810T SINGLE PHASE	16067		1
	4810-700-2	MODEL 810T TWO PHASE	16067		2
	4810-700-3	MODEL 810T THREE PHASE	16067		3
	-7	P.C. BOARD	16067	1-57000	4
		EYELET - SEE SHT. 3			5
					6
C1	*	CAPACITOR			7
C2	*	CAPACITOR			8
C3	*	CAPACITOR			9
C4	*	CAPACITOR			10
C5	DD 152	CAPACITOR 1500 pf	71590	6-10543	11
C6	CM05E750J03	CAPACITOR 75 pf	04062	6-10020	12
C7	VX5A205	CAPACITOR 2 μf 50V	12406	6-10479	13
C8	CK 502	CAPACITOR .005 μf	71590	6-10078	14
C9	CM05F201J03	CAPACITOR 200 pf	04062	6-10035	15
C10	*	CAPACITOR			16
C11	*	CAPACITOR			17
C12	*	CAPACITOR			18
C13	*	CAPACITOR			19
C14	CE 501	CAPACITOR 500 pf	71590	6-10476	20
C15	CM05F151J03	CAPACITOR 150 pf	04062	6-10030	21
C16	*	CAPACITOR			22
C17	*	CAPACITOR			23
C18	DD 271	CAPACITOR 270 pf	71590	6-10544	24
C19	CM05C100J03	CAPACITOR 10 pf	04062	6-10003	25
C20	*	CAPACITOR			26
C21	1DP-1-103	CAPACITOR .01 μf 100V	04062	6-10084	27
C22	CK 502	CAPACITOR .005 μf	71590	6-10078	28
C23	CM05F201J03	CAPACITOR 200 pf	05062	6-10035	29
C24	*	CAPACITOR			30
C25	VX5A205	CAPACITOR 2 μf 50V	12406	6-10479	31
C26	*	CAPACITOR			32
C27	*	CAPACITOR			33
C28	*	CAPACITOR			34
C29	*	CAPACITOR			35
	* SEE FREQUENCY and PHASE DETERMINING PARTS LISTS				36

MODEL 810T | CALICO P/N 4810-700 | ASSY R.O. A1

TITLE OSCILLATOR ASSEMBLY | SHT 6 OF 10

CALICO — CALIFORNIA INSTRUMENTS CO. SAN DIEGO, CALIFORNIA — CODE IDENT 16067

PARTS LIST

REF. DES.	MFG. NUMBER	DESCRIPTION	CODE IDENT	CALICO STOCK NUMBER	ITEM NO.
C30 thru C38	*	CAPACITOR			37
C39	TE1200	CAPACITOR 1μF 25V	56289	6-10152	38
C40	CK104	CAPACITOR .1μF 50V	71590	6-10129	39
C41	T360C226M025AS	CAPACITOR 22μF 25V	05397	6-10746	40
C42	T360C226M025AS	CAPACITOR 22μF 25V	05397	6-10746	41
C43	CM05FD101J03	CAPACITOR 100PF 500V	81349	6-10027	42
C44	CM05FD101J03	CAPACITOR 100PF 500V	81349	6-10027	43
					44
					45
					46
					47
					48
					49
CR1	IN914	DIODE	JEDEC	3-10118	50
CR2	IN914	DIODE	JEDEC	3-10118	51
CR3	IN5246B	DIODE, ZENER	04713	3-10173	52
CR4	IN5246B	DIODE, ZENER	04713	3-10173	53
CR5	IN5226B	DIODE, ZENER	04713	3-10129	54
CR6	IN5226B	DIODE, ZENER	04713	3-10129	55
CR7	IN914	DIODE	JEDEC	3-10118	56
CR8	IN914	DIODE	JEDEC	3-10118	57
CR9	IN5226B	DIODE, ZENER	04713	3-10129	58
CR10	CIC-702-7	DIODE, ZENER	16067	3-10189	59
					60
IC1	CIC 200-1	INTEGRATED CIRCUIT	16067	3-30134	61
IC2	CIC 200-2	INTEGRATED CIRCUIT	16067	3-30006	62
IC3	CIC 200-5	INTEGRATED CIRCUIT	16067	3-30138	63
IC4	CIC 200-2	INTEGRATED CIRCUIT	16067	3-30006	64
IC5	CIC 200-5	INTEGRATED CIRCUIT	16067	3-30138	65
IC6	CIC 200-2	INTEGRATED CIRCUIT	16067	3-30006	66
IC7	CIC 200-2	INTEGRATED CIRCUIT	16067	3-30006	67
IC8	CIC 200-1	INTEGRATED CIRCUIT	16067	3-30134	68
IC9	CIC 200-2	INTEGRATED CIRCUIT	16067	3-30006	69
IC10	CIC 200-1	INTEGRATED CIRCUIT	16067	3-30134	70
					71
	* SEE FREQUENCY and PHASE DETERMINING PARTS LIST				72

MODEL	CALICO P/N	ASSY R.D.
810T	4810-700	
TITLE	SHT OF	
OSCILLATOR ASSEMBLY	7 10	A1

CALICO — CALIFORNIA INSTRUMENTS CORP. SAN DIEGO, CALIFORNIA — CODE IDENT 16067

PARTS LIST

REF. DES.	MFG. NUMBER	DESCRIPTION	CODE IDENT	CALICO STOCK NUMBER	ITEM NO.
Q1	2N 2102	TRANSISTOR	95303	3-30075	73
Q2	CIC 718	TRANSISTOR	16067	3-30041	74
Q3	3N 138	MOS FET	95303	3-30136	75
Q4	CIC 718	TRANSISTOR	16067	3-30041	76
Q5	CIC 336	TRANSISTOR	16067	3-30015	77
					78
					79
R1	*	RESISTOR			80
R2	*	RESISTOR			81
R3	RN60D3011F	RESISTOR 3.01K 1%	JEDEC	5-60041	82
R4	RC20GF680J	RESISTOR 68 Ω 1/2W 5%	JEDEC	5-20015	83
R5	RC07GF182J	RESISTOR 1.8K 1/4W 5%	JEDEC	5-10058	84
R6	RC07GF182J	RESISTOR 1.8K 1/4W 5%	JEDEC	5-10058	85
R7	RC20GF101J	RESISTOR 100Ω 1/2W 5%	JEDEC	5-20018	86
R8	RC07GF152J	RESISTOR 1.5K 1/4W 5%	JEDEC	5-10057	87
R9	RC07GF104J	RESISTOR 100K 1/4W 5%	JEDEC	5-10100	88
R10	RN60D6191F	RESISTOR 6.19K 1%	JEDEC	5-60201	89
R11	RN60D4992F	RESISTOR 49.9K	JEDEC	5-60115	90
R12	RN60D3010F	RESISTOR 301Ω 1%	JEDEC	5-60200	91
R13	NOT USED	RESISTOR			92
R14	3300A-014-52	RESISTOR 20K .1%	16067	5-80097	93
R15	*	RESISTOR			94
R16	RC07GF681J	RESISTOR 680Ω 1/4W 5%	JEDEC	5-10049	95
R17	RC07GF152J	RESISTOR 1.5K 1/4W 5%	JEDEC	5-10057	96
R18	RC07GF152J	RESISTOR 1.5K 1/4W 5%	JEDEC	5-10057	97
R19	RN60D2002F	RESISTOR 20K 1%	JEDEC	5-60098	98
R20	*	RESISTOR			99
R21	3300A-014-52	RESISTOR 20K .1%	16067	5-80097	100
R22	3300A-014-52	RESISTOR 20K .1%	16067	5-80097	101
R23	3300A-014-51	RESISTOR 10K .1%	16067	5-80096	102
R24	*	RESISTOR			103
R25	3300A-014-53	RESISTOR 22.237K .1%	16067	5-80098	104
R26	RN60D8251F	RESISTOR 8.25K 1%	JEDEC	5-60074	105
R27	RN60C1822F	RESISTOR 18.2K 1%	JEDEC	5-60207	106
					107
	* SEE FREQUENCY and PHASE DETERMINING PARTS LIST				108

MODEL 810T | CALICO P/N 4810-700 | ASSY R.O. A1

TITLE OSCILLATOR ASSEMBLY | SHT 8 OF 10

CALICO — CALIFORNIA INSTRUMENTS CORP. SAN DIEGO, CALIFORNIA — CODE IDENT 16067

PARTS LIST

REF. DES.	MFG. NUMBER	DESCRIPTION	CODE IDENT	CALICO STOCK NUMBER	ITEM NO.
R28	RC07GF152J	RESISTOR 1.5K 1/4W 5%	JEDEC	5-10057	109
R29	RC07GF152J	RESISTOR 1.5K 1/4W 5%	JEDEC	5-10057	110
R30	3305P-1-202	VARIABLE RESISTOR 2K	80294	5-70097	111
R31	RN60C1002F	RESISTOR 10K 1%	JEDEC	5-60081	112
R32	RN60D3320F	RESISTOR 332Ω 1%	JEDEC	5-60009	113
R33	RN60D1821F	RESISTOR 1.82K 1%	JEDEC	5-60202	114
R34	RN60D1001F	RESISTOR 1K 1%	JEDEC	5-60020	115
R35	RN60D1004F	RESISTOR 1M 1%	JEDEC	5-60176	116
R36	RN60D1212F	RESISTOR 12.1K	JEDEC	5-60086	117
R37	3300A-014-64	RESISTOR 1.00K .1%	16067	5-80149	118
R38	78PR500Ω	VARIABLE RESISTOR 500Ω	73138	5-70101	119
R39	3300A-014-49	RESISTOR 4.75K .1%	16067	5-80094	120
R40	RC07GF152J	RESISTOR 1.5K 1/4W 5%	JEDEC	5-10057	121
R41	RN60D1004F	RESISTOR 1M 1%	JEDEC	5-60176	122
R42	RC07GF201J	RESISTOR 200Ω 1/4W 5%	JEDEC	5-10036	123
R43	RC07GF156J	RESISTOR 15M 1/4W 5%	JEDEC	5-10137	124
R44	RC07GF156J	RESISTOR 15M 1/4W 5%	JEDEC	5-10137	125
R45	RC07GF152J	RESISTOR 1.5K 1/4W 5%	JEDEC	5-10057	126
R46	RC07GF103J	RESISTOR 10K 1/4W 5%	JEDEC	5-10076	127
R47	SEE P.L. 4810-400				128
R48	3300A-014-51	RESISTOR 10K .1%	16067	5-80096	129
R49	RN60D6651F	RESISTOR 6.65K 1%	JEDEC	5-60204	130
R50	RC07GF152J	RESISTOR 1.5K 1/4W 5%	JEDEC	5-10057	131
R51	3300A-014-51	RESISTOR 10K .1%	16067	5-80096	132
R52	RC07GF201J	RESISTOR 200Ω 1/4W 5%	JEDEC	5-10036	133
R53	*	RESISTOR			134
R54	U-201-501	VARIABLE RESISTOR 500Ω	71450	5-70125	135
R55	3300A-014-51	RESISTOR 10K .1%	16067	5-80096	136
R56	3300A-014-56	RESISTOR 19.90K .1%	16067	5-80113	137
R57	RC07GF152J	RESISTOR 1.5K 1/4W 5%	JEDEC	5-10057	138
R58	3007P-1-501	VARIABLE RESISTOR 500Ω	80294	5-75068	139
R59	RC07GF201J	RESISTOR 200 Ω 1/4W 5%	JEDEC	5-10036	140
R60	3300A-014-1	RESISTOR 10 K .01%	16067	5-80019	141
R61	3300A-014-1	RESISTOR 10K .01%	16067	5-80019	142
					143
	* SEE FREQUENCY and PHASE DETERMINING PARTS LISTS				144

MODEL 810T — CALICO P/N 4810-700 — ASSY R.O. A1

TITLE OSCILLATOR ASSEMBLY — SHT 9 OF 10

CALICO — CALIFORNIA INSTRUMENTS CORP., SAN DIEGO, CALIFORNIA — CODE IDENT 16067

PARTS LIST

REF. DES.	MFG. NUMBER	DESCRIPTION	CODE IDENT	CALICO STOCK NUMBER	ITEM NO.
R62	RN60D3321F	RESISTOR 3.32K 1%	JEDEC	5-60042	145
R63	RN60D1004F	RESISTOR 1M 1%	JEDEC	5-60176	146
R64	3300A-014-51	RESISTOR 10K .1%	16067	5-80096	147
R65	3007P-1-201	VARIABLE RESISTOR 200Ω	80294	5-70095	148
R66	RC07GF152J	RESISTOR 1.5K 1/4W 5%	JEDEC	5-10057	149
R67	RC07GF201J	RESISTOR 200Ω 1/4W 5%	JEDEC	5-10036	150
R68	*	RESISTOR			151
R69	RC07GF155J	RESISTOR 1.5M 1/4W 5%	JEDEC	5-10144	152
R70	T.B.D.	RESISTOR T.B.D.			153
					154
	*	NAME PLATE			155
	*	DRIVE SCREW			156
					157
	05-3308	SOCKET (MOS FET)	91662	2-40294	158
	24GA	BUSS			159
	RCT05075-7A	TRANSIPAD	19080	2-40296	160
					161
					162
					163
	1416-4	SOLDER LUG	83330	2-50094	164
					165
					166
					167
					168
					169
					170
					171
					172
					173
					174
					175
					176
					177
					178
					179

* SEE FREQUENCY and PHASE DETERMINING PARTS LIST

MODEL	810T	CALICO P/N	4810-700	ASSY R.O.
TITLE	OSCILLATOR ASSEMBLY	SHT 10 OF 10		A1

FREQUENCY AND PHASE DETERMINING PARTS LIST

The following addendum parts list defines value and manufacturing part number of components not listed in the preceeding parts list.

LICO | CALIFORNIA INSTRUMENTS CORP. SAN DIEGO CALIFORNIA | CODE IDENT 16067 | PARTS LIST

REF. DES	MFG NUMBER	DESCRIPTION	CODE IDENT	CAL-U STOCK NUMBER	
C1	[illegible]	CAPACITOR .047µf .5%	[illegible]	[illegible]	
C2	[illegible]	VAR. CAP. [illegible]	[illegible]	[illegible]	
C3	[illegible]	CAPACITOR 470 pf	[illegible]	[illegible]	
C4	[illegible]	CAPACITOR .047µf .5%	[illegible]	[illegible]	
C5	C5 502	CAPACITOR .005µf	71590	6-10078	
C6	[illegible]	CAPACITOR 200 pf	04062	6-10035	
C7	[illegible]	CAPACITOR .053µf 1% 50V	27856		
C8	[illegible]	CAPACITOR .053µf 1% 50V	27856		
C9	[illegible]	CAPACITOR .005µf	71590		
C10	[illegible]	CAPACITOR 200 pf	04062	6-10035	10
C20	[illegible]K	CAPACITOR .047µf 50V	12406	6-10115	
C21	[illegible]K	CAPACITOR .047µf 50V	12406	6-10115	
C22		NOT USED			
C23		NOT USED			23
C24		NOT USED			
C25		NOT USED			
C26		NOT USED			
C27		NOT USED			
C28		NOT USED			
C29		NOT USED			
C30		NOT USED			
C31		NOT USED			
C32		NOT USED			
C33		NOT USED			
C34		NOT USED			
C35	[illegible]-1-622	CAPACITOR .0062 µf	04062	[illegible]	
C36	[illegible]-1-622	CAPACITOR .0062 µf	04062	6-10545	26
	[illegible]-102	NAMEPLATE *	16067	1-60000	27
	* [illegible] "400 H_z .1% 1φ"				28
	TYPE U Hardened Metallic	DRIVE SCREW #00 x 1/8 Lg.	45722	2-10024	29
R1	[illegible]-011-50	RESISTOR 7.37K .1%	16067	5-80095	30
R2	[illegible]-011-50	RESISTOR 7.37K .1%	16067	5-80095	31
R3	[illegible]	RESISTOR 14.3K 1%	JIDEC	5-60205	32
R4	[illegible]	RESISTOR 7.37K .1%	16067	5-80095	33
R5	[illegible]	RESISTOR 7.37K .1%	16067	5-80095	34
R6		NOT USED			35
R7		NOT USED			36

ASSY NO. [illegible]

[illegible] PARTS LIST

400 H_z

APPENDIX A

The following code numbers are from the **Federal Supply Code for Manufacturers Cataloging Handbook H4-1** and its latest supplement. Alphabetical codes have been arbitrarily assigned to suppliers not appearing in the H4 Handbook.

0000A	ElectriCord	Westfield, Pa.
0000B	Tech. Prod. Sales	Sorrento Valley, Ca.
0000C	Jackson Bros.	Waddon, Surrey, England
0000D	Chicago Std. Transformer Co.	Chicago, Ill.
0000E	Use Code #08289	
0000F	Colvern	Santa Monica, Ca.
0000G	Use Code #30983	
0000H	Mial Of Italy c/o Q. C. Components	Los Angeles, Ca.
00141	Pic Design Corp.	E. Rockaway, N. Y.
00544	Metal-Cal Div, Avery Prod. Corp.	Inglewood, Ca.
00656	Aerovox Corporation	New Bedford, Mass.
00779	AMP, Inc.	Harrisburg, Pa.
00853	Sangamo Electric Company	Pickens, S. C.
00866	Goe Eng. Co., Inc.	City of Industry, Ca.
01121	Allen-Bradley Company	Milwaukee, Wis.
01255	Litton Industries, Inc.	Beverly Hills, Ca.
01281	TRW Semiconductors, Inc.	Lawndale, Ca.
01295	Texas Instruments, Inc.	Dallas, Tex.
02335	Fairchild Controls Corp.	Hicksville, LI, N. Y.
02660	Amphenol Corporation	Broadview, Ill.
02799	ARCO Capacitors, Inc.	Los Angeles, Ca.
03507	General Electric Company	Syracuse, N. Y.
03508	General Electric Company	Syracuse, N. Y.
03516	General Electric Company	Somersworth, N. H.
03797	Eldema Corporation	Compton, Ca.
03888	Pyrofilm Resistor Co., Inc.	Cedar Knolls, N. J.
03911	Clairex Corporation	New York, N. Y.
04009	Arrow-Hart and Hegeman Elec. Co.	Hartford, Ct.
04062	Use Code #02799	
04713	Motorola Semiconductor Prod., Inc.	Phoenix, Ariz.
04963	3-M	St. Paul, Minn.
05276	Pomona Electronics Co., Inc.	Pomona, Ca.
05397	Kemet, Union Carbide Corp.	Cleveland, Ohio
05820	Wakefield Engineering, Inc.	Wakefield, Mass.
06184	Conelco Components	San Bernadino, Ca.
06223	Kooltronic Fan Company	Princeton, N. J.
06229	Electrovert, Incorporated	Mt. Vernon, N. Y.
06514	Stantron, Wyco Metal Products	N. Hollywood, Ca.
06540	Amathom Elect. Hardward	New Rochelle, N. Y.
07088	Kelvin Electric Company	Van Nuys, Ca.
07256	Silicon Transistor Corp.	Garden City, N. Y.
07263	Fairchild Camera and Instr. Corp.	Mt. View, Ca.
07387	Birtcher Corporation	Los Angeles, Ca.
07556	Unitrack, Calabro Plastics	Upper Darby, Pa.
07716	IRC, Incorporated	Burrington, Iowa
08065	Accurate Rubber and Plastics Co.	San Diego, Ca.
08289	Blinn-Delbert Co., Inc.	Pomona, Ca.
08718	Use Code #71468	
08730	Vemaline Products Co.	Franklin Lakes, N. J.
09026	Babcock Electronics Corp.	Costa Mesa, Ca.
09145	Atohm, Technical Industries, Inc.	Burbank, Ca.
09353	C and K Components, Inc.	Newton, Mass.
11432	Diamond Metal Sales	Gardena, Ca.
11815	Cherry Rivet Div., Townsend Co.	Santa Ana, Ca.
12020	Ovenaire, Incorporated	Charlottesville, Va.
12143	Bendix Corporation	Santa Ana, Ca.
12405	Hysol Corporation	El Monte, Ca.
12406	Elpac, Incorporated	Fullerton, Ca.
12463	Omtronics Mfg., Incorporated	Omaha, Neb.
12697	Clarostat Mfg. Co., Incorporated	Dover, N. H.
13103	Thermalloy Company	Dallas, Tex.
13454	Texas Crystals	River Grove, Ill.
14099	Semtech Corporation	Newbury Park, Ca.
14655	Cornell-Dubilier Elect. Corp.	Newark, N. J.
14752	Electro Cube, Incorporated	San Gabriel, Ca.
15112	Electra Scientific Corporation	Fullerton, Ca.
15801	Fenwall Electronics	Framingham, Mass.
15818	Amelco, Teledyne, Incorporated	Mt. View, Ca.
15909	Use Code #17870	
15912	Digital Sensors, Incorporated	Los Angeles, Ca.
16067	California Instruments Company	San Diego, Ca.
16758	Delco Radio Div., General Motors	Kokomo, Ind.
16902	Simpson Instruments, Inc.	Escondido, Ca.
17745	Angstrohm Precision, Inc.	Van Nuys, Ca.
17838	Mektron, California General, Inc.	Chula Vista, Ca.
17870	Daven Div., Thomas A. Edison	Manchester, N. H.
18121	Wilshire Foam Products, Inc.	Gardena, Ca.
18702	Ducommun Metals and Supply Co.	Los Angeles, Ca.
18722	RCA	Mountaintop, Pa.
19080	The Robinson Company	Hawthorne, Ca.
19781	Potter Company	Sun Valley, Ca.
20857	South Bay Cable Corp.	Gardena, Ca.
21604	Buckeye Stamping Company	Columbus, Ohio
22599	Elastic Stop Nut Corporation	Van Nuys, Ca.
23039	Deccofelt Products Company	Glendora, Ca.
23050	Product Components Corp.	Hastings-on-Hudson, N. Y.
23783	British Radio Electric Ltd.	Washington, D. C.
23936	Pamotor, Incorporated	San Francisco, Ca.
24931	Specialty Connector Co., Inc.	Indianapolis, Ind.
25684	Victoreen Instrument Co., Inc.	Oak Lawn, Ill.
25706	Daburn Electronics and Cable Corp.	New York, N. Y.
26528	Lamcor, Incorporated	Anaheim, Ca.
26533	Zero Manufacturing Company	Burbank, Ca.
27014	National Semi-Conductor Corp.	Santa Clara, Ca.
27191	Cutler-Hammer, Inc.	Milwaukee, Wisc.
27556	IMB Electronic Products	Santa Fe Springs, Ca.
80223	United Transformer Co. (Late Entry)	New York, N. Y.
27683	Varo, Incorporated	St. Garland, Tex.
28520	Heyman Mfg. Company (Heyco)	Kenilworth, N. J.
30086	I-T-E Circuit Breaker Co.	Philadelphia, Pa.
30817	Instrument Specialties Co.	Little Falls, N. J.
30983	Electra/Midland	San Diego, Ca.
42190	Muter Company	Chicago, Ill.
44655	Ohmite Manufacturing Company	Skokie, Ill.
45722	Parker-Kalon	Clifton, N. J.
46384	Penn. Eng. and Mfg. Corp.	Doylestown, Pa.
56289	Sprague Electric Company	North Adams, Mass.
58474	Superior Electric Company	Bristol, Ct.
59730	Thomas and Betts Company	Elizabeth, N. J.
60741	Triplett Electrical Instrument Co.	Bluffton, Ohio
63743	Ward Leonard Electric Co.	Mt. Vernon, N. Y.
70903	Belden Manufacturing Co.	Chicago, Ill.
71002	Birnbach Radio Company, Inc.	New York, N. Y.
71279	Cambridge Thermionic Corp.	Cambridge, Mass.
71400	Bussmann Mfg. Div., McGraw-Edison Co.	St. Louis, Mo.
71450	CTS Corporation	Elkhart, Ind.
71468	ITT Cannon Electric, Inc.	Los Angeles, Ca.
71590	Centralab Div., Globe-Union, Inc.	Milwaukee, Wis.
71785	Cinch Manufacturing Company	Chicago, Ill.
72259	Nytronics, Incorporated	Berkeley Heights, N. J.
72619	Dialight Corporation	Brooklyn, N. Y.
72982	Erie Technological Products, Inc.	Erie, Pa.
73138	Beckman Instruments, Inc.	Fullerton, Ca.
73559	Carling Electric, Inc.	West Hartford, Ct.
73734	Federal Screw Products, Inc.	Chicago, Ill.
73899	JFD Electronics Company	Brooklyn, N. Y.
73949	Guardian Electric Mfg. Co.	Chicago, Ill.
73957	Groov-Pin Corporation	Ridgefield, N. J.
74193	Heinemann Electric Company	Trenton, N. J.
74276	Signalite, Incorporated	Neptune, N. J.
74542	Hoyt Electrical Instrument Works	Penacook, N. H.
74545	Harvey Hubbell, Inc.	Bridgeport, Ct.
74970	E. F. Johnson Company	Waseca, Minn.
75382	Kulka Electric Corporation	Mt. Vernon, N. Y.
75915	Littelfuse, Incorporated	Des Plaines, Ill.
75987	Use Code #95987	
76055	Mallory Controls	Frankfort, Ind.
76348	Miller Products Company	New York, N. Y.
76493	J. W. Miller Company	Los Angeles, Ca.
76854	Oak Manufacturing Company	Crystal Lake, Ill.
77342	Potter and Brumfield Div., Amer. Machine and Foundry Company	E. Princeton, Ind.
78189	Shakeproof Div., Illoms Tool Works	Chicago, Ill.
78299	Struthers-Dunn, Incorporated	Pitman, N. J.
78488	Stackpole Carbon Company	St. Marys, Pa.
78526	Stanwyck Winding Company, Inc.	Newburgh, N. Y.
78553	Tinnerman Products, Inc.	Cleveland, Ohio
78947	Ucinite Company	Newtonville, Mass.
79130	Johns-Manville Products, Corp.	Chicago, Ill.
79727	Continental-Wirt Electronics Corp.	Phila., Pa.
79963	Zierick Mfg. Corporation	New Rochelle, N. Y.
80112	G. C. Electronics Company	Los Angeles, Ca.
80294	Bourns, Incorporated	Riverside, Ca.
80368	Sylvania Electric Products, Inc.	New York, N. Y.
81073	Grayhill, Incorporated	La Grange, Ill.
81095	Triad Transformer Corp.	Venice, Ca.
81312	Winchester Electronics	Oakville, Ct.
81349	Military Specs., Standardization Division, Directorate of Logistic Services DSA	
82389	Switchcraft, Incorporated	Chicago, Ill.
82877	Rotron Manufacturing Co., Inc.	Woodstock, N. Y.
83058	Car Fastener Company	Cambridge, Mass.
83324	Rosan, Incorporated	Newport Beach, Ca.
83330	Herman H. Smith, Inc.	Brooklyn, N. Y.
83594	Burroughs Corporation	Plainfield, N. J.
83701	Electronic Devices, Incorporated	Yonkers, N. Y.
84171	Arco Electronics, Inc.	Great Neck, N. Y.
86684	RCA	Harrison, N. J.
87034	Marco-Oak Industries	Anaheim, Ca.
88026	Use Code #27191	
88245	Useco Div., Litton Industries	Van Nuys, Ca.
90201	Mallory Capacitor Company	Indianapolis, Ind.
91637	Dale Electronics, Inc.	Columbus, Neb.
91662	Elco Corporation	Willow Grove, Pa.
91812	Janco Corporation	Burbank, Ca.
91833	Keystone Electronics Corp.	New York, N. Y.
91929	Micro Switch Div., Honeywell, Inc.	Freeport, Ill.
92194	Alpha Wire Corporation	Elizabeth, N. J.
92219	Waldom Electronics, Inc.	Chicago, Ill.
93332	Sylvania Electric Products, Inc.	Woburn, Mass.
94222	Southco, Incorporated	Lester, Pa.
95146	Alco Electronics Products	Lawrence, Mass.
95303	RCA	Cincinnati, Ohio
95416	Use Code #95146	
95987	Weckesser Company, Inc.	Chicago, Ill.
96682	Genisco, Incorporated	Compton, Ca.
97954	U. S. Components, Incorporated	Bronx, N. Y.
98159	Rubber Teck, Incorporated	Gardena, Ca.
98278	Microdot, Incorporated (Lerco)	S. Pasadena, Ca.
98978	IERC	Burbank, Ca.
99392	STM Corporation	Oakland, Ca.
99515	Marshall Industries	Monrovia, Ca.
99517	Vacco Industries	El Monte, Ca.
99800	Delevan Electronics Corporation	Aurora, N. Y.

ONE YEAR WARRANTY

CALIFORNIA INSTRUMENTS COMPANY a division of AIKEN INDUSTRIES INC. warrants each instrument manufactured by them to be free from defects in material and workmanship for a period of one year from the date of shipment to the original purchaser. Excepted from this warranty are tubes, fuses, and batteries which carry the warranty of their original manufacturer where applicable. CALIFORNIA INSTRUMENTS COMPANY will service, replace, or adjust any defective part or parts, free of charge, when the instrument is returned to the Company freight prepaid, and when examination reveals that the fault has not occurred because of misuse or abnormal conditions of operation. Equipment repaired beyond the effective date of warranty or when abnormal usage has occurred will be charged at applicable rates. CALIFORNIA INSTRUMENTS COMPANY will submit an estimate for such charges before commencing repair if so requested.

PROCEDURE FOR SERVICE

If a fault develops, notify CALIFORNIA INSTRUMENTS COMPANY or its local representative, giving full details of the difficulty, and including the model number and serial number. On receipt of this information, service data or shipping instructions will be furnished. If shipment is indicated, forward the instrument, freight prepaid, to the authorized repair station indicated in the instruction. If requested, an estimate of the charges will be made before the work begins, provided the instrument is not covered by the warranty.

DAMAGE IN TRANSIT

The instrument should be tested as soon as it is received. If it fails to operate properly, or is damaged in any way, a claim should be filed with the carrier. A full report of the damage should be obtained by the claim agent, and this report should be forwarded to us. CALIFORNIA INSTRUMENTS COMPANY will advise the disposition to be made of the equipment and arrange for repair or replacement. Please include model number and serial number when referring to the instrument.

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